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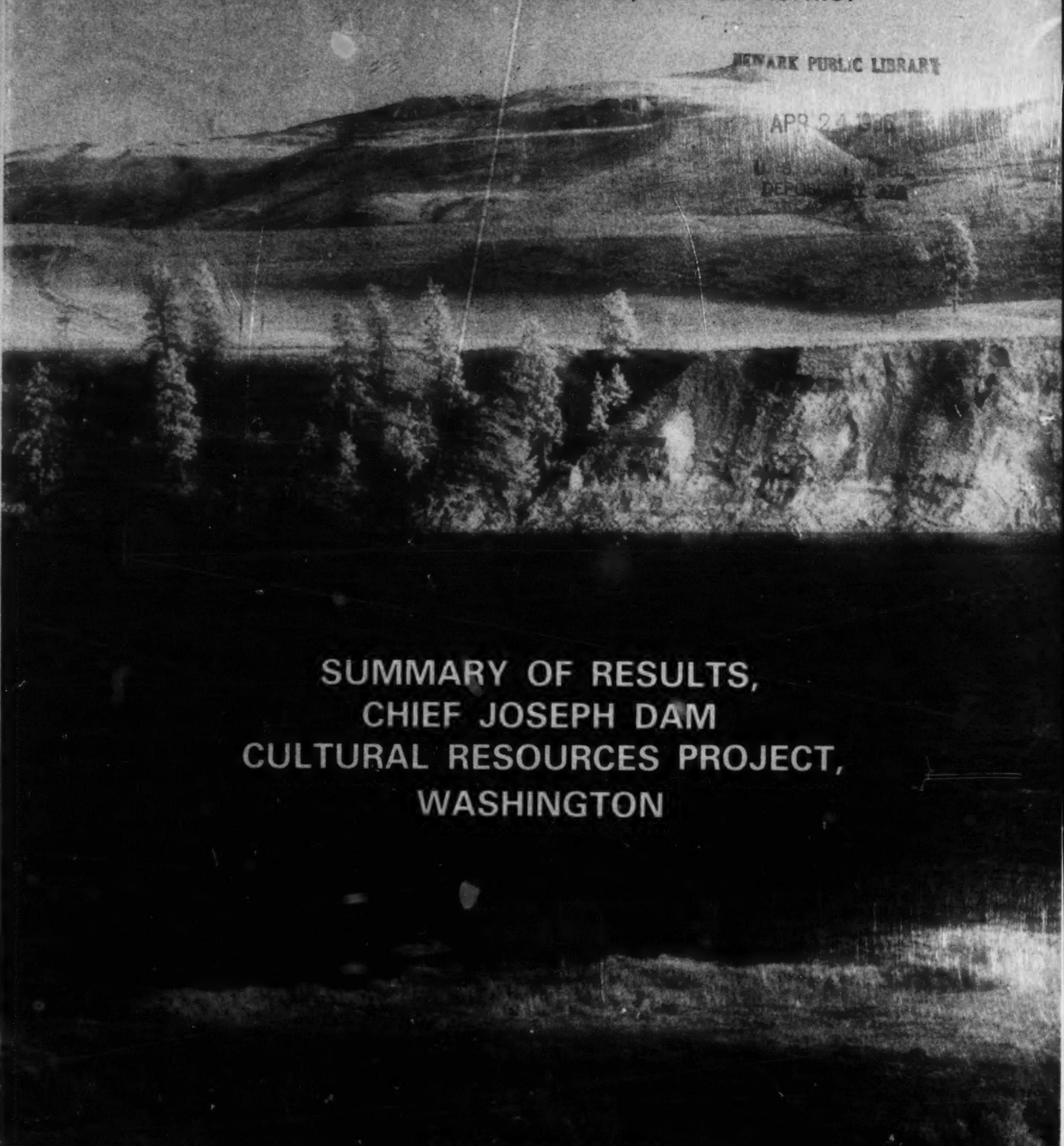

SUMMARY OF RESULTS,
CHIEF JOSEPH DAM
CULTURAL RESOURCES PROJECT,
WASHINGTON

S.K. Campbell, editor

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SUMMARY OF RESULTS, CHIEF JOSEPH DAM CULTURAL RESOURCES PROJECT, WASHINGTON

edited by
Sarah K. Campbell

with contributions by:
V. Cavazos, R. Dalan, P. Davis, D. Hibbert,
L.A. and L.L. Leeds, E. Leopold, S. Livingston, E. Lohse
C. Miss, R. Nickmann, L. Salo, D. Sammons-Lohse,
N. Stenholm, and K. Whittlesey

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Principal Investigators

R.C. Dunnell 1978-1984
D.K. Grayson 1978-1981
M.E.W. Jaehnig 1981-1984
J.V. Jermann 1978-1981

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The technical findings and conclusions in this report do not necessarily reflect the views or concurrence of the sponsoring agency.

Office of Public Archaeology
Institute for Environmental Studies
University of Washington

1985

ABSTRACT

This document summarizes results of the Chief Joseph Dam Cultural Resources Project, a salvage program carried out by the Office of Public Archaeology, University of Washington under contract to the U.S. Army Corps of Engineers, Seattle District. Between July 1978 and August 1980, intensive excavations were conducted at eighteen prehistoric habitation sites on the floodplain and lower terraces of the Columbia River on the 45-mile stretch of river above Chief Joseph Dam. This reach of the river, the lower section of the Upper Columbia, lies between the arid, basaltic Columbia Plateau and the forested, granitic Okanogan Highlands and includes portions of the traditional territories of two Native American groups, the Sanpoil-Nespelem and Southern Okanogan.

This report summarizes findings at a project-wide scale. General descriptive information about the regional assemblage is presented, and arguments are developed supporting inferences about the organization of local subsistence and settlement systems and changes in them through time. The concept of the continuum between collecting and foraging economic systems is used as the major interpretive framework. The first section, comprising a model of prehistoric resource productivity and activity chain descriptions, introduces the study of the evolution of hunter-gatherer adaptation and describes many of the cultural and environmental parameters to be considered in interpreting the project area prehistory. Results of paleoenvironmental studies are presented in the second section. In the third section, the analytic units--phases or periods and site types--are defined and the general parameters of site frequency in time and space are established. Chapters in the fourth section describe the faunal, botanical, lithic, projectile point, and feature assemblages. The synthetic chapter which comprises the fifth section integrates information from the foregoing chapters.

On the basis of the artifact, faunal, botanical, and feature data summarized in this report, three phases (approximately 2,000-year periods) can be contrasted. Changes in the organization of cultural activities in the floodplain zone are inferred; these are assumed to reflect the evolution of the entire subsistence and settlement systems of which they are a major part.

Projectile point styles suggest human use of the area may have begun as early as 6500 B.P., but the oldest radiocarbon date associated with cultural material is 5401±343. The earliest period, the Kartar Phase (7,000-4,000 B.P.), was characterized by the broadest resource base, incorporating a wide variety of rodents, artiodactyls, reptiles, and fish in the most even proportions of any period. Year-round base camps (housepit sites) and temporary stations were located in the floodplain zone, but few specialized camps. A variety of upland and floodplain plant and animal foods were stored at the central base; however, storage may have been less effective than in later periods and reliance on winter hunting of artiodactyls greater. Site numbers, and thus possibly population densities, are lower than in later periods, perhaps because a large area was needed to supply winter game and early spring foods. The faunal remains at the temporary stations suggest

opportunistic foraging; they may represent food gathering in early spring when food stores were depleted.

In the Hudnut Phase (4,000 to 2,000 B.P.), the economy became somewhat more specialized, indicated by less even proportions of economic fauna. Population levels evidently increased and people were more widely distributed over the landscape, using some marginal areas. The total number of sites in the floodplain increased and the number of housepit and special camp sites increased in proportion to the number of stations. Housepit sites were dispersed over a greater variety of locations, including the south side of the river, and some housepits evidently were used for only a limited season rather than as year-round bases. While some groups continued to use sites in optimum locations as year-round base camps, other groups shifted between summer and winter base camps.

During the Coyote Creek Phase (2,000 to 50 B.P.) the economy became yet more specialized, with a greater reliance on deer and fish. A greater degree of logistical organization is indicated by increased proportions of specialized camps. Although population levels probably continued to rise, house sites were restricted to the north bank of the river. The degree to which base camps were single season or year-round is uncertain, partly because of a shift around 300 B.P. to surface dwellings rather than pithouses. While considerable continuity of material culture can be traced directly into the reservation period, a number of archaeological patterns--abandonment of stone projectiles, introduction of trade ornaments, a greater number of burials, presence of horses, and the shift to surface houses indicate cultural changes associated with the advent of the historic period. The broad chronological divisions used here do not permit close examination of this period of change.

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PREFACE

This report presents a general summary of findings of the Chief Joseph Dam Cultural Resources Project, a salvage program carried out by the Office of Public Archaeology, University of Washington under contract to the U.S. Army Corps of Engineers, Seattle District. Other project reports provide detailed information about the structure and contents of individual sites; this report concentrates on generalizations about the prehistory of the entire area. This preface addresses the nature and scope of the volume as a whole; introductions to each section provide additional prefatory remarks for individual chapters.

The contract required that the project select a number of sites believed to be representative of site variability--temporal, geographic, and functional--and that we use these as a basis for providing a chronological framework for the region and summarizing the types of cultural adaptations at different times. The summary and interpretation of the prehistory of the Chief Joseph project area presented in this report fulfills this need. It is, however, limited in scope because the contract provided for only a limited amount of synthesis after completion of the individual site reports. This is not a systematic or exhaustive summary, even of the data categories presented in the individual site reports. Although various chapters address most of the data categories found in the individual site reports, e.g. botanical remains, faunal remains, lithic tools, features, etc., it has not been possible to encompass all of the available information. Therefore we concentrated on selected aspects of the data which seemed particularly fruitful and interesting for a pioneering summary.

The papers comprising this volume were written, not as a concerted effort, but by individual authors at different times. Some chapters provide background information on non-cultural aspects of the environment, some concentrate on cultural contents in a primarily descriptive manner, while several address a common theme--understanding the evolution of the hunting-gathering adaptation in the area. This rather broad goal could be said to apply to much of Plateau archaeology without necessarily implying any unity of approach. In this report, integration is provided by the large-scale units used--the site types, the three periods/phases, and by reference to the concept of the continuum from collecting to foraging systems. However, the authors view different aspects of the archaeological record and do not necessarily reach the same conclusions.

We are pleased to present one of the first regional summaries based on systematic quantitative comparisons of multiple sites. Some of the generalizations we make about changes through time are not new; the same patterns have been perceived by other researchers who have defined phases and described their characteristics. For example, researchers in other reaches of the Columbia River have noted an increase in the number of sites after 4000 B.P. and an expansion of sites into marginal areas as we have. And, researchers throughout the Plateau have noted the same changes in material frequency--a decrease in the use of basalt and an increase in the use of cryptocrystalline siliceous materials through time. Our contribution is to emphasize quantitative summaries of large-scale archaeological units--periods and site types--which empirically support these observations.

The methodological issues and biases involved in generalizing from this data base are emphasized throughout. The project data demonstrates the complex variability of the archaeological record in the floodplain zone. Continuous changes in the organization of activities in the floodplain zone are indicated by the changing relative frequency of different types of sites. The contents of a particular site type in one phase may be more similar to the contents of that site type in another phase than to other site types in the same phase. Such observations highlight the importance in Plateau studies of establishing comparable and appropriate analytic units for purposes of drawing inferences about time periods and settlement patterns.

The single chapter in Section I is a paper on modelling taken from an early draft research design which was never published. Although outdated in some ways, this modelling attempt sets the stage for the remainder of the report, with a discussion of the study of hunter-gatherer subsistence systems on the Plateau, and delineation of environmental variables which may have influenced cultural development.

Papers dealing with paleoenvironmental data are in Section II and Appendices B and C, although Chapters 12 and 13 on faunal and botanical remains in Section IV apply as well to paleoenvironmental reconstruction. These papers provide background information pertinent to interpreting cultural adaptations in the area.

The Section III papers address the distribution of archaeological materials (sites, components, categories of refuse) in time and space. The large-scale analytic units (phases/periods, site types) with which we construct our generalizations about the prehistory of the area are introduced in Chapter 6.

Papers on specific categories of site contents are included in Section IV. Separate chapters deal with lithics, projectile points, faunal remains, botanical remains, and features.

Section V contains a single chapter synthesizing data from the preceding chapters. Emphasis is on a broad picture--a summary of the various generalizations which can be made about areal prehistory, our confidence in the generalizations, and important issues which have not been addressed.

We hope this summary of our findings will sufficiently intrigue some readers to read the individual site reports, and to utilize the data base collected by the project to challenge and build on our conclusions.

ACKNOWLEDGEMENTS

The Chief Joseph Dam Cultural Resources Project depended on the collaboration of many individuals and agencies. During the excavation and early reporting stages, Coprincipal Investigators were Drs. Robert C. Dunnell and Donald K. Grayson, both of the Department of Anthropology, University of Washington, and Dr. Jerry V. Jermann, Director of the Office of Public Archaeology, University of Washington. Dr. Manfred E.W. Jaehnig served as Project Supervisor during this stage of the work. From the autumn of 1981 until the end of 1983, Dr. Jaehnig served as Coprincipal Investigator with Dr. Dunnell.

Three Corps of Engineers staff members have made major contributions to the project. They are Dr. Steven F. Dice, Contracting Officer's Representative, and Corps archaeologists Lawr V. Salo and David A. Munsell. Both Mr. Munsell and Mr. Salo have worked to assure the success of the project from its initial organization through site selection, sampling, analysis, and report writing. Mr. Munsell provided guidance in the initial stages of the project and developed the strong ties with the Colville Confederated Tribes essential for the undertaking. Mr. Salo gave generously of his time to guide the project through data collection and analysis. In his review of each report, he exercises that rare skill, an ability to criticize constructively.

We have been fortunate in having the generous support and cooperation of the Colville Confederated Tribes throughout the entire length of project. The Tribes' Business Council and its History and Archaeology Office have been invaluable. We owe special thanks to Andy Joseph, representative from the Nespelem District on the Business Council, and to Adeline Fredin, Tribal Historian and Director of the History and Archaeology Office. Mr. Joseph and the Business Council, and Mrs. Fredin, who acted as liaison between the Tribe and the project, did much to convince appropriate federal and state agencies of the necessity of the investigation. They helped secure land and services for the project's field facilities and to establish a program which trained local people (including many tribal members) as field excavators and laboratory technicians. Beyond this, their hospitality has made our stay in the project area a most pleasant one. In return, conscious of how much gratitude we wish to convey in a few brief words, we extend our sincere thanks to all the members of the Colville Confederated Tribes who have supported our efforts, and to Mrs. Fredin and Mr. Joseph, in particular.

Initially this report was to have been edited by Dr. Jaehnig and myself, but his time was otherwise committed when the project got underway. I would like to acknowledge the extensiveness of his indirect contributions to this

report through his guidance and administration of the project during the final stages of analysis and the writing of the descriptive site reports. Dr. Jaehnig made a firm commitment to team research, working hard to facilitate and coordinate this approach, and yet at the same time allowed latitude to individual researchers. The research atmosphere that he established was essential to completing the project and arriving at the conclusions that are presented here.

The cooperation I received from contributing authors made my task as editor considerably easier and more satisfying. Interactions with the authors who wrote their sections after I began putting the report together were stimulating and helped determine the direction of the report. Authors of previously written pieces that were selected for inclusion were gracious about digging into their old files to answer questions about text details, bibliographic references, and figures. Because of time restrictions, it was not possible for each author to review each draft of the report; I take full responsibility for final editorial decisions and apologize for any damage done.

I extend my sincere thanks to Lawr Salo, Randall Schalk, Stephanie Livingston, and Virginia Butler for commenting on parts or all of drafts of this report. Chapters 1 and 7 benefited from previous editing by Linda Leeds, and Chapters 2 and 13 from editing by Marc Hudson and Helen Mundy-Hudson.

Philippa Colley, Patricia Ruppé, Natalie Cadoret, and Dawn Brislawn all contributed to word processing and other production tasks for earlier drafts. Production of the camera ready copy was accomplished by Sarah Campbell. Figures for Chapters 1, 7 and Appendix A were taken from the manuscripts in which these sections originally appeared. Bob Radek and Melodie Tune drafted the geologic maps in Chapter 2 and some of the Chapter 11 figures, the Chapter 8 figures were drafted by Lawr Salo, and the remainder of the drafting was done by Sarah Campbell. The cover photograph was shot with infrared film near 45-OK-2 by Larry Bullis, and the cover layout designed by Bob Radek.

SECTION I: MODELLING PREHISTORIC SUBSISTENCE STRATEGIES AND ACTIVITIES

The first chapter in this volume presents an approach to modelling prehistoric cultural subsistence systems in the project area. It is a combination of two chapters of the draft research design (Jermann et al. 1980). The introduction of the current chapter is taken from the chapter "Research Contexts" written by Leon Leeds. The remainder of the chapter originally appeared as "Model Building", written by project staff members Leon Leeds, Linda Leeds, and Karen Whittlesey. Two complementary kinds of models are considered. The first is an economic model, in which environmental data is used to produce a qualitative description of the relative abundance of resources in time and space. The reason for performing this modelling is because ethnographies: a) conflict; b) have limited temporal applicability; c) are not very specific; and d) do not cover many important points. In the second, activity chain descriptions of subsistence activities are developed from ethnographic and other data. Although the activity chain analyses included here emphasize outputs in bounded area (hearths, dwelling, and villages) the potential importance of this approach lies more in providing expectations for unbounded units (e.g., skin-dressing and butchering).

This approach to explaining archaeological data reflects general archaeological research interests at the time it was conceived; a number of systemic models were developed in the late 1970's. However, the modeling approach was not pursued beyond this point, and project research activities began to head in other directions, partly because of the practical constraints of the contract requirements, and partly because of weaknesses in the modelling approach itself. Many of the assumptions made in the economic model are invalid or overly simplistic. For example, recent wildlife studies have shown that previous studies underestimated the abundance of deer, so the de-emphasis of artiodactyl resources is probably overdone. The consideration of the possibility of environmental change is weak. Secondary paleoenvironmental data is relied on and no good argument is given for the assumption of lack of environmental change. Although the authors argue that they would not extrapolate resource quantities derived from modern studies into the past, they do extrapolate the temporal/spatial structure of resource availability into the past, without a serious discussion of the kinds of quantitative changes which might amount to qualitative changes in structure. Further, our work has resulted in observations about important aspects of local prehistoric cultures not even addressed in these models.

The chapter has not been updated in view of later findings, but is left essentially as it was presented in 1980, with editorial but only a few minor substantive changes. Because the theoretical approach described here dictated many of the project's data collection goals, this document provides an important context for understanding project results.

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1. MODEL BUILDING AS AN APPROACH TO EXPLAINING EVOLUTION OF HUNTER-GATHERER ADAPTATIONS ON THE COLUMBIA PLATEAU

by Leon L. Leeds, Linda A. Leeds, and Karen A. Whittlesey

While the "Paleo-Indian" and "Archaic" periods always have been of interest to some New World prehistorians, and some thought was early directed towards classifying subsistence-settlement networks from Archaic site distributions (e.g., Winters 1969), the study of hunter-gatherer systems has only recently become a major focus of the field. Toward the end of the 1960's the changing climate of public and scientific opinion about the nature of ecological systems and industrial culture, coupled with pioneering studies of hunter-gatherer subsistence input-output and demographics (Lee and DeVore 1968; Lee 1969), effected a revolution in attitude toward the adaptive strategies of hunting-gathering systems (Sahlins 1972: Chapter 1). Since the advent of ecological concepts in anthropology and archaeology (e.g. Rappaport 1969; Trigger 1971; Hardesty 1977), archaeologists have begun a systematic and scientific study of hunter-gatherer subsistence, settlement, and dynamics (e.g., Thomas 1972, 1973; Casteel 1972; Yellen and Harpending 1972; Hayden 1972; Wobst 1974; Jochim 1976; Yellen 1977a, 1977b; Binford 1978a, 1978b, 1980; Rick 1980; Lynch 1980).

Hunter-gatherer systems in general can be classified along the dimension of **seasonal movement** (wandering, central-based, sedentary) and **degree of resource specialization** (intensive, extensive). **Wandering** groups follow available resources, while **sedentary** groups find most resources within easy round trip distance of a central location. **Central-based** groups exploit resources over a broader area than sedentary groups, but unlike wanderers they return frequently to a resource-rich central area and spend an appreciably greater amount of time there than in other procurement locations. Both wandering and sedentary groups may either focus **intensively** on a single kind of resource--such as sea mammals, large herd animal, anadromous fish, or a major vegetable product; or they may focus **extensively** on a number of kinds of resources--such as roots, seeds, fruits, small and large game, fish, and shellfish--balancing these in various proportions.

Intensive wandering systems based on scavenging or hunting of herd animals are often referred to as **serial foraging systems,** while extensive wandering systems, usually biased toward plant foods with lesser elements of small or large game, are referred to as **general foraging systems.** Central-based settlement networks are most often coupled with extensive subsistence systems and generally are found in habitats with great temporal and spatial disparity in food type and availability during the year, the central base providing shelter and protected facilities for food storage during winter or other seasons of low productivity. Binford (1980) introduced the term **logistical** to refer to central-based and sedentary hunter-gatherers who move resources to a central locality, in contrast to wandering groups, or foragers, who move the entire community frequently to locations of previously unexploited resources.

THE STUDY OF HUNTER-GATHERER SYSTEMS ON THE COLUMBIA PLATEAU

The prehistory of the Columbia Plateau is the prehistory of hunting-gathering systems. Information from studies concerned primarily with local or regional chronology (Daugherty 1956; Cressman et al. 1960; Swanson 1962; Sanger 1969; Nelson 1969; Grabert 1968, 1974; Leonhardy and Rice 1970; Irwin and Moody 1977; Chance and Chance 1977) implies a continuous record of hunter-gatherer settlement from about 12,000 B.P. to the period of European settlement. Few of these studies, however, have been designed specifically to investigate subsistence-settlement systems. Hunter-gatherer communities exploit a variety of habitats in the course of a single year. Although Plateau habitats vary greatly with elevation and physiographic feature, from floodplain to plateau and/or forested highland, most archaeological work has been focused on single sites or on a haphazard "sample" of sites in floodplains of the Columbia River system. Consequently, reported site assemblages are unlikely to accurately reflect the full range of variation within cultural systems.

Nevertheless some indications of system variation do exist. While local chronologies exhibit relatively similar sequences of chronological changes with respect to projectile points styles, intraregional variability in lithic assemblages appears to correspond to regional and local environmental differences (Browman and Munsell 1969; Grabert 1974; Chance and Chance 1977). In addition, at least three studies demonstrate functional variation of activity loci in extrariverine environments (Dancey 1973; Smith 1977; Uebelacker 1978).

Three regional syntheses describing a historic sequence of culture change have established the general framework of Plateau prehistory up to this point (Daugherty 1962; Nelson 1969; Browman and Munsell 1969). While these differ somewhat in chronology, transition period, interpretation of subsistence focus, and culture-forming process, all focus on four of the six possible types of hunter-gatherer systems and provide a more or less consistent evolutionary sequence from a wandering/intensive (large game or fish) to a wandering/extensive (small game, roots, seeds, fresh-water mussels) to a central-based extensive (fish, game, plant foods) to a central-based intensive system (anadromous fish, some game, and plant foods) (Figure 1).

Sites of the earliest, or "Windust", phase (ca. 11,000-8,000 B.P.) occur in the Columbia, Snake, and Palouse River floodplains or in scabland coulees (i.e. in riverine or lacustrine environments), in rockshelters, or less frequently, on low river terraces. As inferred from recovered tool and faunal assemblages, the occupations represent small groups--possibly two to three extended families--engaged in butchering, secondary food preparation, hide-working, and tool manufacture (Rice 1972). The faunal assemblages include mainly species of artiodactyls--deer (*Odocoileus* spp.), elk (*Cervus elaphus*), antelope (*Antilocapra americana*), some bison (*Bison bison*), occasional salmonid vertebrae, and some freshwater mussel shell (Margaritiferidae). The preponderance of food remains varies from site to site; fish remains are most abundant at The Dalles, bison remains at Lind Coulee, and other artiodactyls at the Windust and Marmes Rockshelters (Nelson 1969:104; Rice 1972). With respect to subsistence, interpretations of these remains may vary. While a "big game" focus would strongly suggest a wandering/intensive, or serial foraging, system, a primary focus on fish by small, seasonally coherent groups would suggest at least the possibility of a dispersed sedentary/intensive system, one not contemplated by the above-mentioned sources.

Seasonal Movement	Subsistence Focus	
	Intensive	Extensive
Central-Based	(ca. 350 - 150 BP) L. CAYUSE ← fishing, hunting gathering	(ca. 2000 - 350 BP) E.-M. CAYUSE fishing, hunting, gathering
Wandering	(ca. 11000 - 8000BP) WINDUST → "Big Game" hunting or fishing	↑ (ca. 8000 - 2000 BP) VANTAGE-QUILOMENE BAR hunting, gathering

Figure 1-1. Temporal sequence of hunter-gatherer system changes on the Plateau suggested by regional syntheses (Daugherty 1962; Nelson 1969; Browman and Munsell 1969).

Most sources describe the phase from about 8000 to 2000 B.P. (Vantage-Quilomene Bar) as characterized by wandering/extensive, or general foraging, systems. They explain the inferred shift to small game, roots, and seeds as a response to the warmer, drier conditions of the Altithermal and to contact with peoples migrating from the Great Basin (Nelson 1969:105).

While no research yet undertaken on the Plateau has sampled or analyzed both cultural and environmental resources at a scale appropriate for characterizing subsistence-settlement systems, there are theoretical reasons, at least, for doubting that the pioneering occupations on the Plateau represent either serial or general foraging. As Binford has recently pointed out, environments supporting wandering/extensive systems occur in equatorial and semitropical climatic zones (Binford 1980:14), where critical resources tend to be continuously available and evenly distributed; the proportion of such ethnographic systems observed outside those environments is very low. Although climatic fluctuations during the Holocene are apparent in the Plateau region, pollen and other paleecological analyses suggest no fundamental redistributions of faunal and floral species. Plateau conditions have probably been warm-to-cool temperate with considerable seasonal variability in temperature and moisture throughout the Holocene. Under such a climatic regime, critical resources are periodically absent and geographically dispersed. Serial foraging based on the systematic exploitation of herd animals seems equally unlikely. While this strategy can be effective in temperate grassland environments, the Plateau probably never supported such large ungulate populations as those on the Great Plains. The growth and recovery characteristics of bunchgrass in the Columbia Plateau region suggest a marked absence of grazing stress throughout the Holocene up to European occupation (Daubenmire 1970:7). Bison, which occurred in large herds on the Great Plains, are rare in Plateau sites; no systematic kill sites or butchering localities analogous to those in the Great Plains are known. The ungulates more commonly represented in sites, elk, deer and antelope do not commonly occur in large herds, although elk and deer become more social in the winter.

Because resources in the Plateau region (water, winter shelter, fuel, wood products, roots, green, fruits and seeds, fish and/or meat) are not available at all times and locations, a logistical strategy (Binford 1980) would be required to adapt either an intensive or an extensive hunter-gatherer economy to Plateau conditions. Such a model could explain rockshelter and open camp occupations in the floodplain as winter settlements or base camps for the exploitation of riverine resources and would predict (1) division of the community for simultaneous exploitation of geographically incongruent resources, (2) techniques of food preservation and provisions for storage, (3) a variety of kill and butchering loci, and (4) temporary residential camps to facilitate collection and processing of vegetable foods and forest resources. The lack of fish or vegetable food remains at many of the rockshelters does not necessarily contradict interpretation of them as base camps. If these foods were prepared at or near where they were obtained, few remains would be left when they were consumed at residential base camps. Only the bones of animal species hunted and returned to the winter settlement for immediate consumption are likely to be well represented at residential sites.

Most authors, however, suggest the shift from foraging systems to a central-based (winter village) system took place around 2000 (±500) B.P. The period from 2000 B.P. to the present is regarded as the time when riverine adaptations similar to those documented in the ethnographic record were established. The period is characterized by the winter village, the origin of semisubterranean dwellings, and the first serious reliance on fish (Nelson 1973). The change to the winter village system has been variously explained as a cultural response to climatic change (Daugherty 1962), environmental catastrophe (Sanger 1967), independent invention (Swanson 1962), migration (Nelson 1969), or a combination of migration and diffusion (Warren 1968; Nelson 1973; Smith 1977).

Of particular concern to the field in recent years has been the study of demography of hunter-gatherer populations in relation to varying environmental conditions and exploitation strategies. Information potentially of value for demographic studies includes the size of settlements and the kind, size, and arrangement of individual dwellings. Surveys of settlement and community pattern information both on a broad, regional scale (e.g. Warren 1960) and for particular locales (Swanson 1958; Grabert 1971; Stryd 1971) have documented considerable variation in settlement/house size and arrangement through both time and space on the Columbia Plateau. For example, Grabert (1971) has hypothesized a temporal shift in community settlement organization and pattern for the Okanogan River Valley. Three general changes are observed: (1) settlement increase in number through time; (2) the number of dwellings per settlement increases through time, except in the north (British Columbia), where single-dwelling settlements are most common late in the cultural sequence; and (3) the size and depth of individual dwellings decrease through time. Grabert suggests that these apparent changes can be attributed to increases in population size and a shift from multifamily to nuclear family residence. The introduction of the horse late in the eighteenth century also is thought to be a factor.

In his investigation of British Columbia data, Stryd (1971) notes that large pit houses seldom occur by themselves and that there is a patterned arrangement of large and small housepits in sites where both occur. He proposes three hypotheses to account for the observed variability: (1) differences in housepit size may reflect different functions (e.g., residences, ceremonial structure, workshops, sweat lodges, etc.); (2) differences in housepit size may be a function of variation in social rank among residential units; and (3) variable housepit sizes may be due to differences in family stability, more stable families residing in larger structures. Although some data have been presented to document the variability (Stryd and Hills 1972), none of the proposed explanations have been tested. While these studies imply the feasibility of population dynamic studies, they also suggest the possibility of a sedentary (dispersed or nuclear) settlement coupled with nonagricultural subsistence. The probable reason a sedentary system has never been seriously contemplated for the Plateau region is that although such systems are ethnographically documented for such areas as the Pacific Northwest and California coasts, the ethnographic literature for the Plateau region (principally Ray 1932 and Spier 1938) documents only central-based, extensive or intensive subsistence systems. As will be discussed later, however, there is good reason not to dismiss such possibilities out of hand.

MODEL BUILDING

We suggest model building as an approach to the study of prehistoric systems in the Plateau region. Models are analogues of cultural systems designed to imply (predict) archaeologically observable consequences at some scale (e.g., frequency of functional artifact classes in different areas of a settlement; frequency of classes, occupations, or sites per ecozone; population density per spatial unit and temporal unit; etc.). Testing involves matching expectations derived from the model wih data derived from sampling.

In the few areas blessed with detailed ethnographic records, one can formulate a model applicable to archaeological information and derive test consequences to compare with a subsequent sample of archaeological material from the region covered by the ethnography. For example, starting with Stewards's (1938) ethnography of Shoshonean subsistence and settlement patterns, Thomas (1972, 1973) constructed a computer simulation model of subsistence activities and seasonal scheduling to predict proportions of tool types and their spatial patterning across four ecozones in a section of the Reese River Valley, Nevada. While a number of important assumptions not easily accessible in the ethnographic literature appear to be embedded in Thomas' program, the general approach from direct ethnography to prehistoric settlement organization is valid. An alternative to simulation modeling is activity pathway and chain analysis (House 1975; Schiffer 1975b, 1976) which lead from experimental or ethnographic data to suggested assemblages and spatial arrangements that might be associated with different kinds of sites or activities.

From more distant analogues and from economic and ecological theory, one can model general settlement pattern and demography. Working from economic principles and assumptions of hunter-gatherer economic goals and resource management procedures, Jochim (1976) derived a series of functions to predict activity scheduling, activity location, and demography and tested these using data on distribution of Mesolithic sites in southwestern Germany.

STRATEGY

We have used both of the modeling processes discussed above, economic modeling from environmental information and chain modeling from direct ethnography. The two are both supplementary and complementary at various points. Together they potentially offer a relatively detailed description of hunter-gatherer subsistence and settlement, given the current state of economic, environmental, and archaeological theory. Where economic modeling predicts broad patterns of settlement location and land use, chain analysis from ethnography suggests the outputs and output clusters that might be associated with different systems.

Information about resource availability and spatial/temporal distribution, at least qualitatively, is necessary to supplement modeling from ethnographic sources. Some sampling and analysis of environmental data are necessary to specify the geographic locations of resources. While economic modeling holds some promise for predicting overall settlement distribution and demographics and for explaining system change, one must have a system description to start with. Jochim (1976), for instance, assumes he is dealing with a foraging system, although this is never explicitly stated among his premises. Modeling from ethnography provides a basis for selecting from a wide variety of potential resources those actually involved in determining use scheduling, activity area location, and demographics. Moreover, economic modeling has little power, in most instances, to predict actual artifact distributions. Its weakness lies in the articulation of expectations with observed archaeological data. Chain analysis from detailed ethnographic sources describes expected output materials and features at a variety of spatial scales from element through cluster, occupation, habitat, and zone. Consequently, it is ideal for directing artifact analysis and spatial analysis. Nevertheless, inference from ethnographic analogy is only applicable to a limited range of the prehistoric record. Economic analysis, for as far back as the environmental analogy holds, can account for a variety of possible systems states, suggesting reasonable ways to alter the ethnographic model to predict other kinds of systems once the archaeological data suggest that such a change would be warranted.

Working from ethnographic data to prehistoric contexts assumes a degree of homeostasis and provides an organizational (or structural) description of prehistoric systems only for some specific period of time. Where expectations do not well match observed archaeological data, changes in the model would presumably allow description of a sequence of system states. The starting model is expected to hold for the most recent prehistoric periods, while considerable adjustments are anticipated to cover data patterns from earlier periods of occupation.

ASSUMPTIONS

Both models are developed within a systemic approach. Human cultures are not **composed**, of course, of system components, subsystems, or variables; such concepts are **imposed** on the cultural "reality" by the researcher. Given a systemic context of research, the number of components describing the system is potentially infinite, and all linkages are recursive to some degree. The choice of components, variables, and their relationships is determined by research goals and approach.

Many archaeological studies of subsistence economy rely upon a deterministic relationship between environmental and cultural components. The "driver" in Thomas' (1972, 1973) system, for instance, is a combination of the cyclic productivity of the pinon nut, Indian rice grass, and antelope, while in Zubrow's (1975) system it is zonal population and agricultural productive capacity. Jochim assumes resource use scheduling to be the primary determinant of site placement and demographic arrangement (1976:13) and at a later point in his analysis considers carrying capacity to be a determinant of demographics (1976:71). All of these researchers assume the "environment" is in some way culturally determined, but that assumption is more or less implicitly embedded in their analysis. Jochim assumes, for instance, a foraging, (or wandering, extensive) system with a certain resource base. Central-based, sedentary hunter-gatherer systems, agricultural systems, and industrial systems might use the same local environment quite differently.

We assume that the set of cultural activities, their relations to the environment, and the resource base thus determined form a buffer between environmental variability and variability in the cultural systemic context (Figure 2). Scheduling, location, and structure of activities, and in turn, demography, are primarily determined by the resource base, although some important recursions must be considered, and activity location and structure are also demonstrably related to variables of the physical environment.

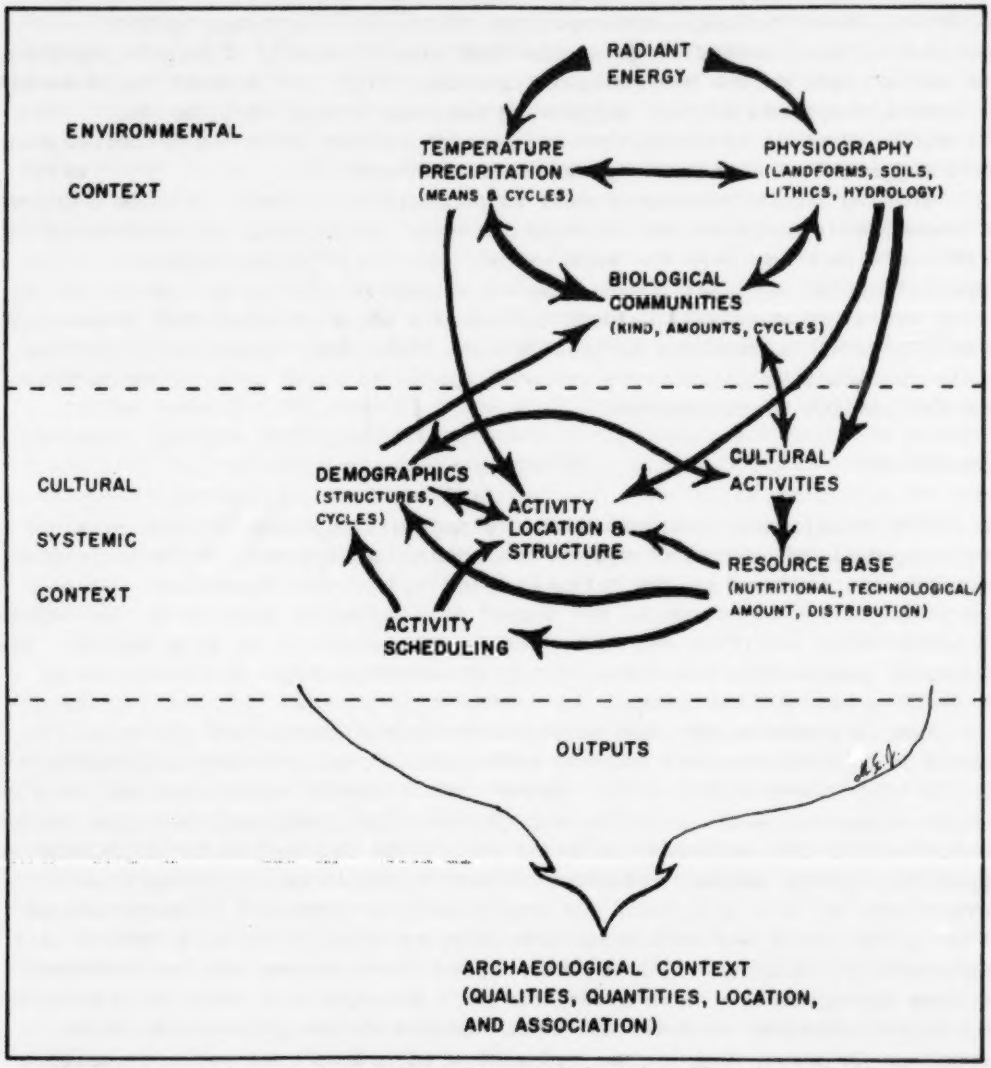

RADIANT ENERGY
ENVIRONMENTAL CONTEXT
TEMPERATURE PRECIPITATION (MEANS & CYCLES)
PHYSIOGRAPHY (LANDFORMS, SOILS, LITHICS, HYDROLOGY)
BIOLOGICAL COMMUNITIES (KIND, AMOUNTS, CYCLES)
CULTURAL SYSTEMIC CONTEXT
DEMOGRAPHICS (STRUCTURES, CYCLES)
ACTIVITY LOCATION & STRUCTURE
CULTURAL ACTIVITIES
RESOURCE BASE (NUTRITIONAL, TECHNOLOGICAL/ AMOUNT, DISTRIBUTION)
ACTIVITY SCHEDULING
OUTPUTS
ARCHAEOLOGICAL CONTEXT (QUALITIES, QUANTITIES, LOCATION, AND ASSOCIATION)

Figure 1-2. Interrelation of environmental and cultural systemic variables.

ENVIRONMENT AND ECONOMIC MODELING

We assume that variables critical to the cultural system are physiography, vegetation, climate, and the effect of climate and vegetation cycles on wildlife populations and distribution. Some economic models incorporate quantification of such environmental attributes as species (or material type), geographic distribution, weight (live, dressed, dry), density (per zone, habitat, and season), aggregate size (number in group or community), and yield (usable or edible material, nutritional profile, etc.). There is insufficient local environmental information to quantify these attributes in the study area, nor is it theoretically defensible to extrapolate from modern data into the past. Our emphasis here is on environmental qualities that would affect the relative abundance of resources in time and space, not absolute quantities.

The study area proposed here includes twenty townships in Okanogan and Douglas Counties, and two half-townships in Ferry County, Washington (Figure 1-3) and is centered on a long northward bend of the Columbia River between Chief Joseph and Grand Coulee Dams. Most environmental studies, including archaeological work performed by the Office of Public Archaeology, concentrate on the floodplain and nearby features of the valley escarpment (USACE 1975; Payne et al. 1976; Fielder 1977; Erickson 1980; West 1980; Hibbert, this volume). More general sources cover the Columbia Plateau and Okanogan Highland regions to the north and south (Rodgers 1942; Hitchcock 1955-1969; Daubenmire and Daubenmire 1968; Daubenmire 1970; Franklin and Dyrness 1973).

PHYSIOGRAPHY, LITHOLOGY, AND HYDROLOGY

The Columbia River Canyon separates the study area into two broad provinces. To the south (left side) is the basaltic Columbia Plateau. To the north lie the Okanogan Highlands, primarily composed of acid plutonic basement rock, although a lobe of the basaltic Plateau projects well north of the river between the Omak Trench and the Okanogan River. On the basis of physiographic features, basement rock, soil development, hydrology, and biomes, the area may be separated into three broad divisions, with major subdivisions, resulting in seven distinct biophysiographic zones (Figures 1-4 and 1-5). Zone IIIL (L=Left bank) encompasses a flat basaltic plateau consisting of poorly developed lithic soils, shallow scabland coulees, low mesas, and numerous pothole lakes, many of which are seasonally dry and some of which are saline. Zones IIIR (R=Right bank) and IV consist of dissected tableland with an average elevations between 600 m (2,000 feet) and 900 m (3,000 feet) m.s.l. and higher, rounded massifs above 900 m. Zones IIL and IIR consist of the higher glacio-lacustrine terraces, alluvial fans, canyons, and ridge systems which form the escarpment of the Columbia canyon. Compared to the right (north) side, the left (south) side is steeper and less deeply dissected, has fewer perennial aquifers and fewer remnant terraces, and throughout the study area is generally more shadowed from direct sunlight. Zone I, the river itself and its floodplain, consists of the lowest glacio-lacustrine terraces, current and relict beaches, draws and canyon mouths, alluvial fans, and river-

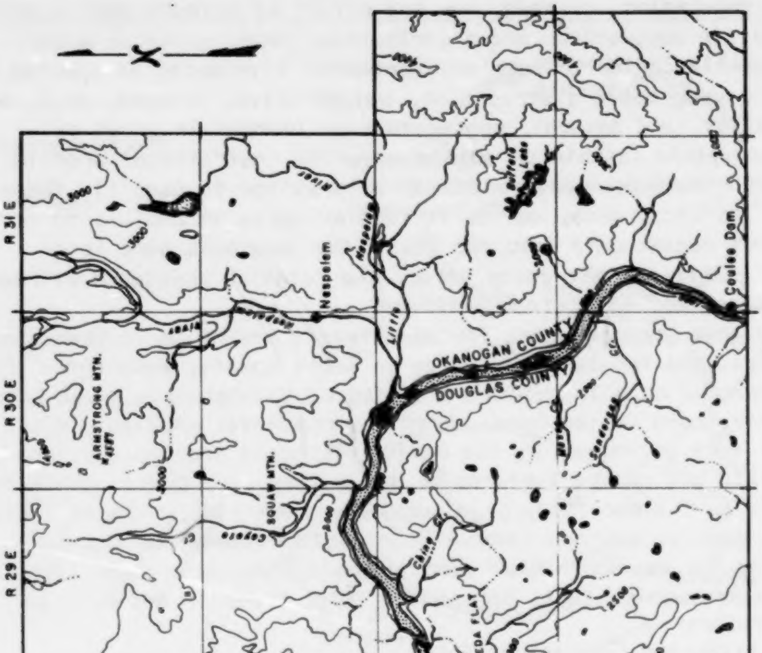

LEGEND
Columbia River Rapids
River Islands
0 5 10 Km.
0 5 10 Mi.
WASHINGTON STATE
Seattle
AREA LOCATION
R 26 E
R 29 E
R 30 E
R 31 E
T 31 N
T 30 N
T 29 N
OKANOGAN COUNTY
DOUGLAS COUNTY
ARMSTRONG MTN.
SQUAW MTN.
Nespelem
Coulee Dam
ALAMEDA FLAT
RUFUS WOODS LAKE
CHIEF JOSEPH DAM
Buffalo Lake
Coyote
Little Nespelem
Nespelem River
Sanderson Cr.
3000
2500
2000

Figure 1-3. Vicinity map of study region.

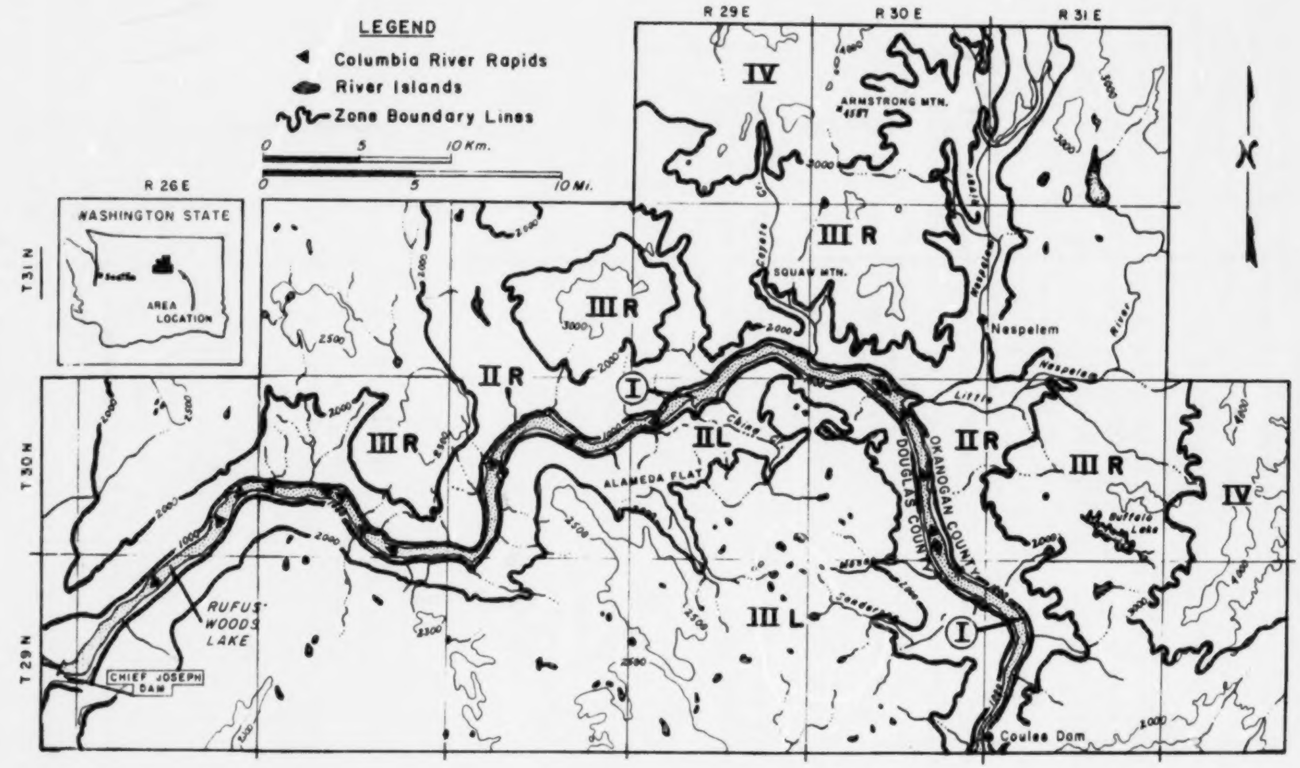

LEGEND
Columbia River Rapids
River Islands
Zone Boundary Lines
0 5 10 Km.
0 5 10 Mi.
WASHINGTON STATE
Seattle
AREA LOCATION
R 26E
R 29E
R 30E
R 31E
T 31 N
T 30 N
T 29 N
N
IV
III R
II R
III L
II L
I
ARMSTRONG MTN.
4587
SQUAW MTN.
Coyote Cr.
Nespelem
Nespelem River
Little Nespelem
ALAMEDA FLAT
China Cr.
DOUGLAS COUNTY
OKANOGAN COUNTY
Buffalo Lake
Coulee Dam
RUFUS WOODS LAKE
CHIEF JOSEPH DAM
1000
2000
2500
3000
4000

Figure 1-4. Distribution of proposed physiographic zones in the study area.

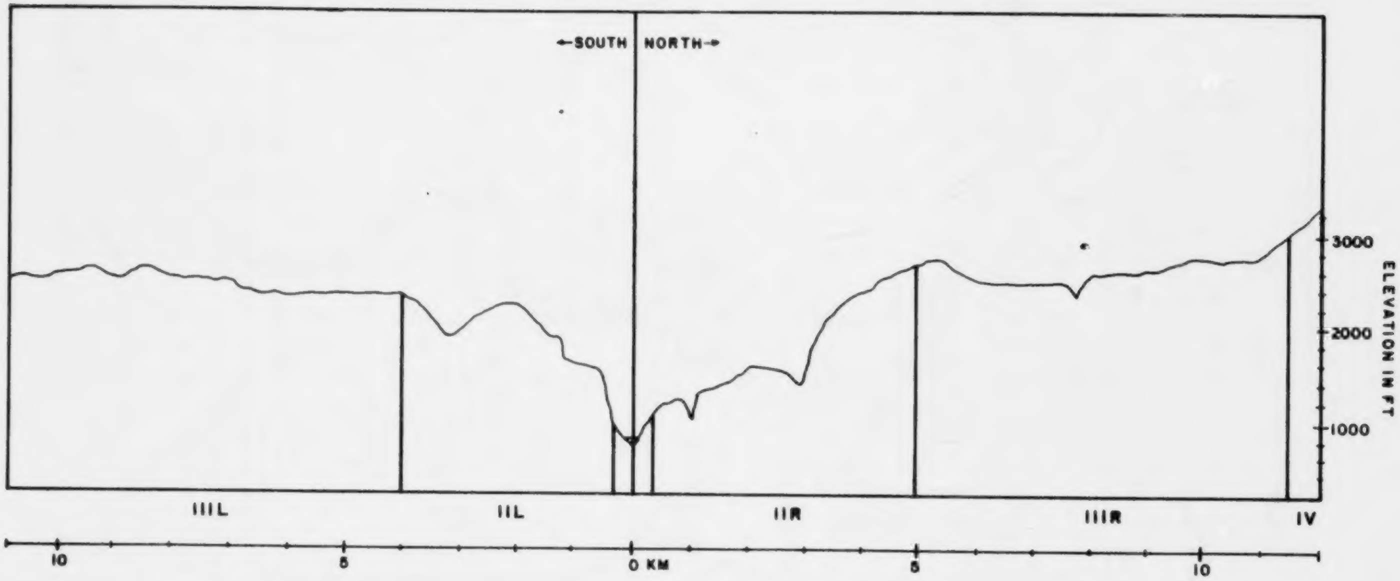


Figure 1-5. Lateral transect of study region showing physiographic zones.

cut bluffs. Like Zone IIL, the terrestrial part of Zone I on the south bank, Zone IL, is distinguished from its counterpart on the north bank, Zone IR, by steeper slopes, lower amounts of indicident sunlight, fewer relict terraces, rockier soils, and steeper bluffs.

While occasional cryptocrystalline materials are found in Zone I along river beaches, beach lithics are primarily composed of transported basaltic, granitic, and quartzitic cobbles and gravels. While no systematic sampling has been performed, very fine-grained basalts are primarily observed in Zone IIIL, on the Columbia Plateau. Cryptocrystalline deposits are most likely to be accessible in Zones IIL and IIR below the Omak Trench, and Zone IIL (Salo, Appendix F; Key and Cavazos, Appendix G).

Drainage into the Columbia River is primarily from the north; the most prominent drainage courses are creeks in the vicinity of Belvedere, the Nespelem and Little Nespelem Rivers, Coyote Creek, Hopkins Canyon, the Omak Trench, and Tumwater Basin. While the first three have annual surface flows, the remainder are intermittent. Sanderson Creek and Strahl Canyon provide the major drainage from the Waterville Plateau to the south (Figure 1-3). While there are a few artesian aquifers, the aquifers in general consists of seasonally and annually variable groundwater deposits in draws and at the bases of talus slopes.

It is important to note that while there has been much fluvial cutting and redeposition of the lower river-margin terraces and some modification of alluvial fans and entrenchment of draws. The bulk of evidence to date suggests that the physiography of the region has remained essentially unchanged since shortly after the close of the Pleistocene (Hibbert, this volume; Crozier 1980 and personal communication). We assume that physical variables (other than climatic changes) affecting the structure and distribution of plant, animal, and cultural communities may be taken as a constant throughout the period of prehistoric occupation.

VEGETATION

Three major terrestrial biomes occur in the study area: a shrub-steppe, corresponding to Zones I, IIR, IIL, and IIIL, a ponderosa pine forest, corresponding to Zone IIR, and mixed Douglas fir and grand fir forest, corresponding to Zone IV (Daubenmire and Daubenmire 1968; Daubenmire 1970; Franklin and Dyrness 1973). While Daubenmire (1970) distinguishes the steppe proper from the moister steppe-meadow on the basis of environmental reconstruction, the steppe vegetation of the study area is characterized by big sage brush (Artemisia tridentata) dominant over the introduced cheat grass (Bromus tectorum), with only occasional communities of the original bunchgrass species surviving over-grazing in the late nineteenth and early twentieth centuries. In general, the steppe before A.D. 1800 would have been characterized by various proportions of big sagebrush and small, or "three-finger," (A. tripartita) over a variety of bunchgrasses (Agropyron, Festuca, Poa, etc.).

It is important here to emphasize three aspects of this general pattern. First, the three vegetation zones are not neatly or definitively structured by elevation. In addition to normal interfingering and series reversals on north-facing slopes, the shrub-steppe and the understory of the ponderosa pine in Zones II and IIIR are characterized by a complex mosaic of alternating dominants--including big-sagebrush, small sagebrush, bitterbrush (*Purshia tridentata*), and, in recently disturbed areas, rabbitbrush (*Chrysothamnus nauseosus*)--or by grasses alone. In addition to bitterbrush or grass, the Symphoricarpos union (*Symphoricarpos albus*, *Rosa woodsii*, *R. nutkana* and *Spiraea betulifolia*) (Daubenmire and Daubenmire 1968) forms the dominant undergrowth in more mesic areas higher in Zone IIIR. Second, the pine and Douglas fir forests covering parts of Zone IIIR and Zone IV extend west only to the Omak Trench, beyond which is the basaltic Omak Plateau, covered by the shrub-steppe mosaics characteristic of Zones II and IIIL. Third, the shrub-steppe habitat in Zones I and II is punctuated by a variety of small habitat types associated with draws, canyons, rocky slopes, talus slopes, and standing water.

A baseline study of the terrestrial part of Zone I distinguished 14 habitat types, five of which are distinct island communities (Erickson et al. 1977). The structure and distribution of these communities is expressed in Tables 1-1 and 1-2. While a few sample transects were performed during this study, the extent was calculated from air photos and the tabulation somewhat underestimates the extent of the macrophyllous vine and shrub and the broadleaf tree over shrub habitats, which are frequently distributed only as thin lines along talus slopes and at the bases of outcrops. While the acreage of all but the shrub-steppe habitat is small, some of the smaller, lusher habitats support disproportionately large wildlife communities, and nearly all of the dominant species of the smaller habitats are important nutritional and/or technological elements in the ethnographically recorded resource base. The habitats dominated by coniferous trees are outliers of the forest zones to the north, and the broadleaf trees and shrubs form larger mosaics at higher altitudes in Zone IIR, IIIR and IV. While the character of Zone IIL is much like that of Zone I, the basaltic lithosols of the steep slopes support considerably less sagebrush, and disproportionately large communities of such root crops as balsamroot (*Balsamorhiza saggitata*), bitter-root (*Lewisia rediviva*), and lomatiums (*Lomatium* spp.). While no formal baseline studies have been performed, during a reconnaissance in the spring of 1980 Dr. Stenholm counted over 400 false onion (*Brodiaea douglasii*), 40 wild carrot (*Lomatium macrocarpum*), and 240 chocolate tips (*Lomatium dissectum*) in a community covering 0.2 hectares in Zone IIL.

The seven physiographic zones, with their characteristic landforms, soils, hydrology, and solar orientation, when intersected by the ten vegetation habitat types, form a complex structure. It is by reference to this structure that the relatively more mobile faunal communities may be located, and it is against the combined pattern that a hunting-gathering system of any type is structured. Time is a third dimension in the system--short, medium, and long frequency cycles of temperature and effective moisture affect the structure of the vegetation communities and, either directly or indirectly, the faunal communities.

Table 1-1. Diversity of habitat types in Zone I of the study region (from Erickson et al. 1977: Table 7:2).

Habitat Type	Symbol	Number of Species			Percent annual herbs	Total species
		Trees	Shrubs	Herbs		
Shrub-steppe	(SS)	0	13	44	16	57
Rock	(RK)	0	9	23	17	32
Rockland	(RL)	0	13	27	26	40
Coniferous tree over shrub layer	(CS)	1	7	5	20	13
Coniferous forest	(CF)	2	14	68	21	84
Macrophyllous vine and shrub layer	(MV)	0	14	26	15	40
Broadleaf trees over shrub layer	(BS)	5	16	40	30	61
Riparian	(RP)	1	6	29	24	36
Mixed coniferous and broadleaf tree over shrub layer	(CB)	5	14	34	20	53
Buckley Bar	(BB)	2	9	35	26	46
Short Island	(IS)	1	4	18	17	23
Goose Island	(IS)	0	4	17	35	21
Park Island	(IS)	0	8	19	26	27
Lone Pine Island	(IS)	1	5	16	25	22

CLIMATE AND ENVIRONMENTAL CYCLES

The climate of the area is semi-arid, characterized by hot, dry summers and cold, somewhat moister winters. Complete weather data are not recorded at Grand Coulee Dam, Chief Joseph Dam, Nespelem, Disautel, or Republic, and documentary sources vary on reported average temperatures and precipitation for the region. Erickson et al. report summer mid-day temperatures averaging from 83°F (28°C) to 94°F (34°C), winter temperatures from 40°F to (4.4°C) to 47°F (8.3°C), and annual precipitation averaging 9.6 inches (24.4 cm) (1977:9). Mean annual precipitation recorded at Nespelem, according to Bureau of Indian Affairs (BIA) records and National Oceanographic and Atmospheric Administration (NOAA) summary reports, is 13.7 inches (34.8 cm). We presume that precipitation increases three inches (7.5 cm) or so for every 2,000 feet (600 m) or elevation from Zone I through Zone IV, and that winter temperatures decrease with elevation. The general climatic profile of the area compared to the humid temperate profile of Europe and the northeastern United States, is presented in Figure 1-6. Indices of evaporation, relative humidity, and effective temperature are not available at this time.

Table 1-2. Distribution of habitat types occurring in Zone I of the study region (from Erickson et al. 1977:Table 7.1).

Habitat Type	Symbol	Total acres	Percent of total area	No. of individual units of each type	Average acreage of each unit	Percent of all unit occurrences
Shrub-steppe	(SS)	12548	68	31	405	10
Agriculture		1828	10	36	51	11
Rock	(RK)	1105	6	60	18	19
Development		1102	6	13	35	4
Rockland	(RL)	553	3	12	46	4
Coniferous tree over shrub layer	(CS)	458	2	40	11	13
Coniferous forest	(CF)	197	1	13	15	4
Macrophyllous vine and shrub	(MV)	184	1	41	4	13
Islands	(IS,BB)	183	1	6	30	2
Broadleafed tree over shrub layer	(BS)	115	1	28	4	9
Riparian	(RP)	105	<1	33	3	10
Mixed coniferous and broadleafed tree over shrub layer	(CB)	46	<1	5	9	1
Total	- - -	18424	100	318	58	100

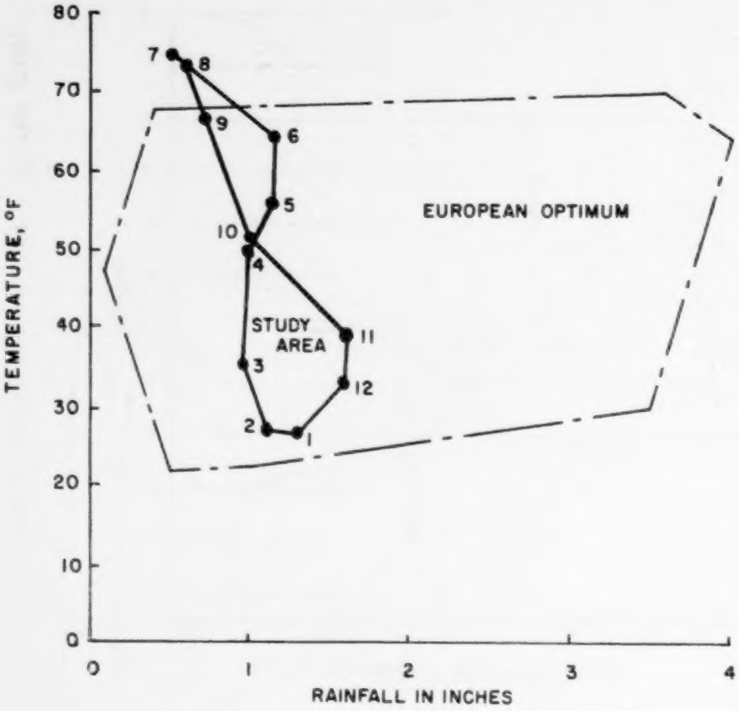


Figure 1-6. Temperature-moisture climatograph compiled from mean monthly temperatures at Grand Coulee Dam and mean monthly precipitation at Nespelem. European optimum profile from Odum (1971).

Short-term Cycles

Three kinds of climatic cycles are important in the study of hunter-gatherer systems. Annual cycles presumably have the greatest effect on demography and scheduling and location of subsistence activities. Mean monthly temperatures and precipitation are shown in Figure 1-7 and snowfall and accumulation are shown in Figure 1-8. While standing crop analyses have not been performed, either in general or by season, we assume that productivity of deciduous vegetation varies directly with the temperature cycle and with rainfall. Informal reconnaissance suggests first sprouting toward the latter part of March in Zone I, flowering in mid to late April, fruit bearing from mid June through August, depending upon species and year, seed availability from late June through September, and leaf loss from November through December. There is an apparent two to four week retardation of the vegetation cycle progressively from Zone I through Zone IV. In dry years, the more mesic conditions in Zones IIIR and IV protect against late summer drought, but first frosts, presumably, come earlier than in Zone I. In all, there are four months of very low productivity (mid November to mid

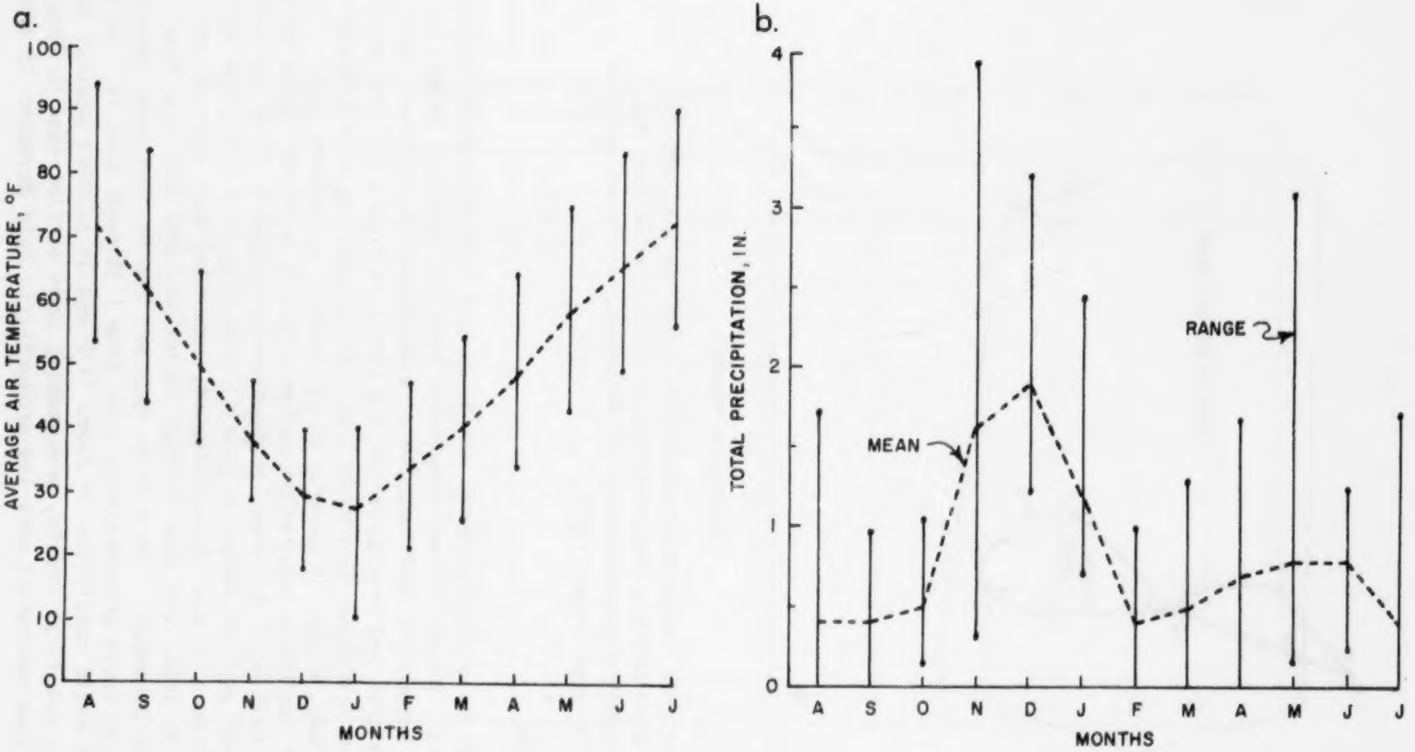


Figure 1-7. Average daily temperature (a) and monthly total precipitation (b) in Zone I of the study region, 1964-1973 (adapted from Erickson et al. 1977:Figure 1.2).

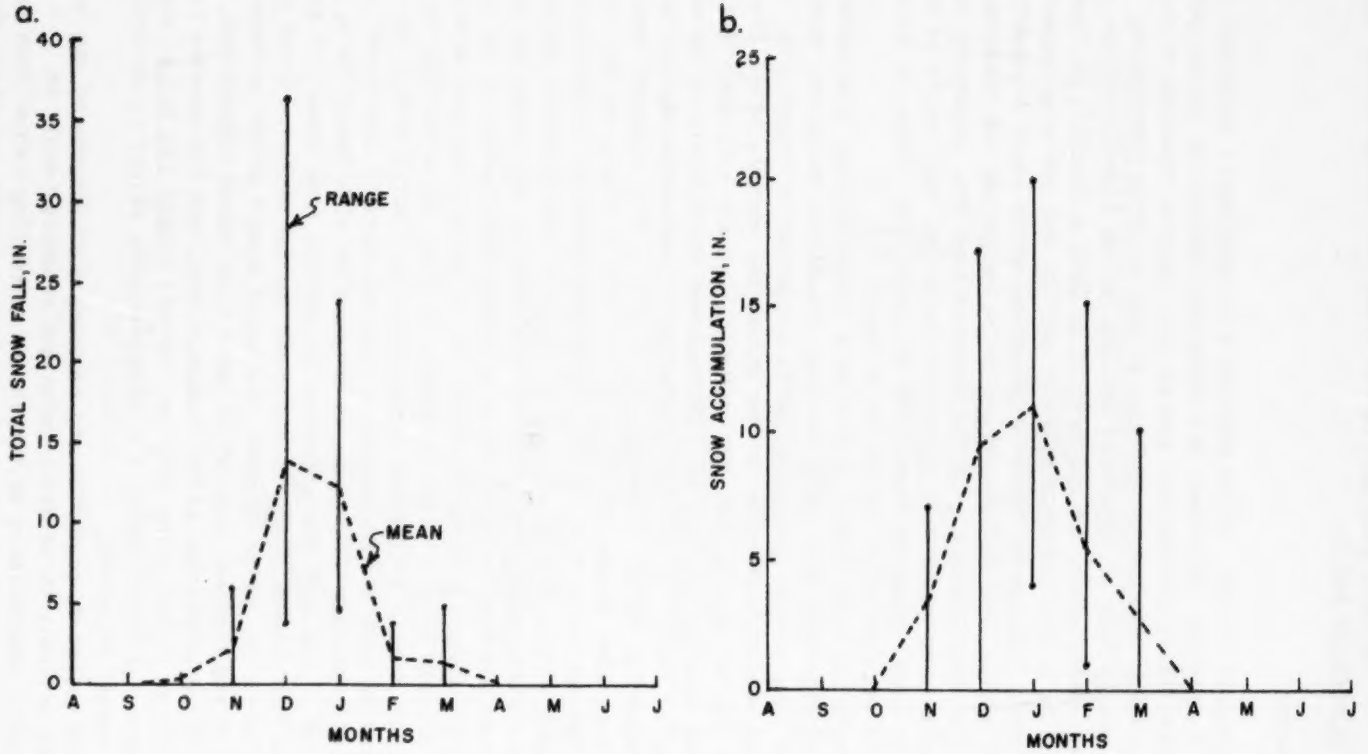


Figure 1-8. Total snowfall (a) and snow accumulations (b) in Zone 1 of the study region, 1964-1973 (adapted from Erickson et al. 1977:Figure 12.2).

March) except for habitats with coniferous trees and non-deciduous sages (principally Artemisia spp.).

Mid-length Cycles

While seasonal cycles, in conjunction with geographic dispersal of physical and biological resources, are important factors in hunter-gatherer subsistence-settlement strategies, cycles with lengths from one to roughly 100 years (encompassing information pathways of one to three overlapping generations) should have an important bearing on the diversification of the resource base. Niche width, we suggest, is as much a function of these cycles, as it is a function of population cycling and carrying capacity (cf. Christenson 1980). Cycles of resource depletion which recur frequently enough within the effective information pathway to be recognized and remembered should result in the broadening of the resource base and, depending upon the temporal-spatial distribution of exploited resources, may result in the under utilization of some resources responsive to scale (i.e., those in which cost decreases with population or man-hours at task).

In a preliminary search for such middle range cycling, precipitation data for 65 years (1915-1980) were obtained from the BIA at Nespelem, Washington. A plot of the mean annual precipitation is presented in Figure 1-9. A series of correlation analyses were run on the annual and monthly data. The most to be said from the pattern is that the probabilities are very good that a year of higher than average rainfall will be followed immediately by one or two of below average rainfall. Since the vegetation in semi-arid regions is extremely responsive to small changes in rainfall, this suggests considerable variability from year to year in the productivity of floral as well as faunal resources. The deviation from monthly mean precipitation is particularly telling (Figure 1-10). As the two graphs suggest, the greatest deviations from average monthly precipitation occur in February, May-June, and November-December. Precipitation in February is a determining factor in the overall availability of annuals and the productivity of perennials, and precipitation in May-June affects longevity during summer months. By affecting the degree of ground cover, precipitation and temperature indirectly affect the condition of local spawning beds and consequently fish harvests in subsequent years. Precipitation in November-December, in conjunction with temperature, affects browse in Zone I, and thus the migration of cervids from Zones III and IV to Zone I for winter shelter (this is discussed further below). Given a climatic regime similar to the one at present, one would expect either extremely low aggregate size and regional population density of human communities, or (1) considerable diversification of the resource base, and (2) seasonally secure resources such as lichen, pine cambium, cattail (Typha latifolia) and other forest and swamp products having a disproportionate weight in determining winter settlement locations.

Moderate cycles of depletion and recovery with lengths of one or two centuries are unlikely to be anticipated and probably result in archaeologically undetectable shifts in use scheduling rather than in radical systemic alterations. On the other hand, abrupt events occurring this

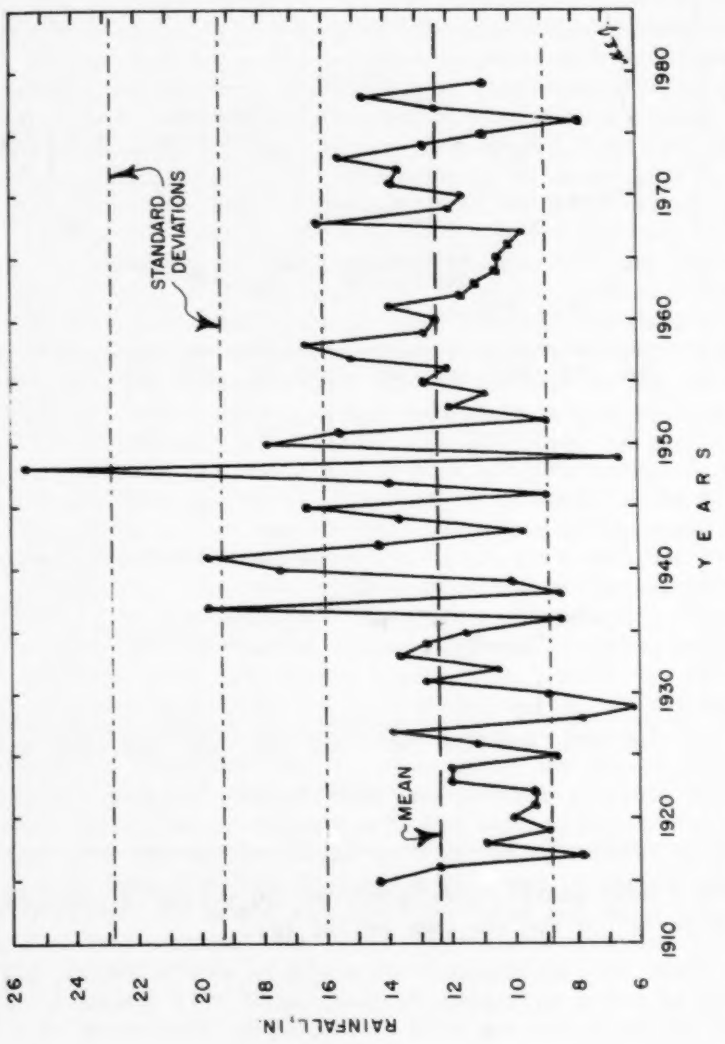


Figure 1-9. Analysis of rainfall at Nespelem, 1915-1980 (from data compiled by the Colville Confederated Tribes).

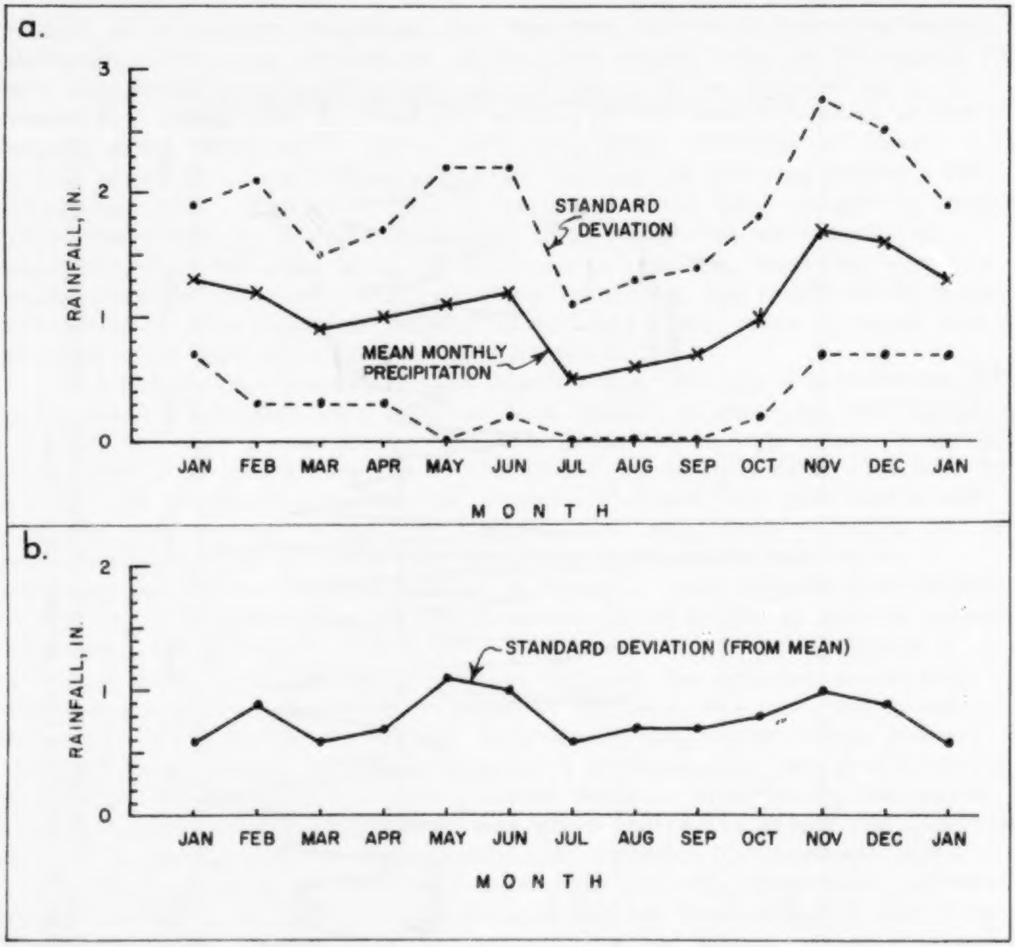


Figure 1-10. Mean monthly precipitation, 1915-1980 (a) and plot of absolute standard deviation for the same period (b).

infrequently may result in quick population losses and slow recoveries, accounting for "hiatuses" in certain periods in local chronologies compared to the same periods in other regions (e.g., Chance and Chance 1977).

Long-term Cycles

From the standpoint of system change, slow but cumulatively radical changes in environment over many centuries are important to document. Paleoclimatic and paleoenvironmental studies applicable to the Plateau in general and to the study area in paricular are mainly based upon cave sediments and pollen analyses. It is generally postulated that there have been four shifts in climate from moister-cooler to warmer-drier conditions during the last 12,000 years. The immediate post-glaciation conditions were cooler and moister than at present, with a peak around 9000 B.P. (Swanson and Muto 1975) and minor fluctuations in this mode up to about 8000 B.P. A cycle of warmer-drier conditions, often referred to as the "Altithermal," was initiated by a brief cold episode followed by an abrupt warming trend between 8000 and 7000 B.P. (Rice 1972), which peaked between 7150 and 5800 B.P. (Swanson and Muto 1975). This was followed, in turn, by cooler and moister conditions between roughly 4500 and 3000 B.P., although the data from different localities suggest different scheduling of episodes. Rice (1972) and Swanson and Muto (1975) suggest two cooling periods in the last 5,000 years, separated by a brief warming trend somewhere around 3000± B.P., while Dalan (see Goose Lake report, this volume) characterizes the entire period from 4000 B.P. to present as cooler and moister (Figure 1-11).

More important than regional fluctuations in climate is the effect of general climatic shifts on the vegetational structure of the specific study area. Pollen cores from lakes in the study region were analyzed to investigate these shifts. The preliminary results from the Goose Lake core have important implications (Dalan, this volume). Correlation of the Goose Lake core with others in the Plateau region suggests climatic trends roughly comparable to those of other areas (see Figure 3-4). While the pollen diagram suggests a significant retreat of the pine forest during the Altithermal, 14), the profiles of other arboreal and nonarboreal species suggest no significant *qualitative* change in the micro-habitat types since the end of the post-glacial pine-spruce parkland regime after approximately 10,000 B.P.

These preliminary results suggest that the main effect of the Altithermal in the study area was the expansion and contraction of vegetation communities. The *Pinus* forest in Zone IIIR was replaced with grass or shrubb-steppe regime. The broadleaf tree over shrub and macrophyllous vine and shrub habitats, associated with draws, canyons, and talus slopes (characterized by *Alnus*, *Betula*, *Populus*, island stands of *Pinus* and *Pseudotsuga* over *Artemisia*, *Sarcobatus*, and *Rosaceae* with forbes such as *Umbelliferae* and *Eriogonum*) continued much as at present, although the coverage and productivity of these habitat types should have been somewhat reduced in Zones I and II.

While a number of factors must be considered in the interpretation of pollen cores (Butzer 1971:247), the general results are not inconsistent with the results of soils analysis from 19 sites in Zone I (Crozier 1980 and

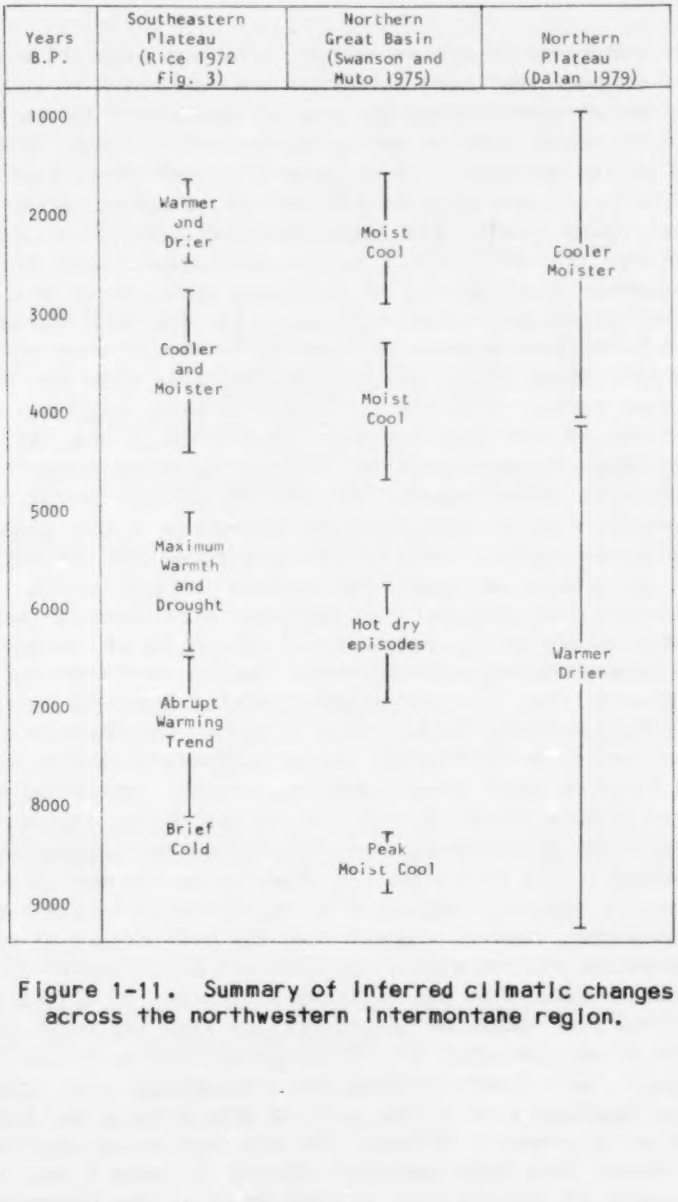


Figure 1-11. Summary of inferred climatic changes across the northwestern intermontane region.

personal communication). Soils and matrices examined in floodplain and fan deposits suggest no radical change of environment in the last 6,000 years. Nevertheless, the mid-Holocene retreat of the pine forest from Zone IIIR to Zone IV, and a reduction of microhabitats in Zones I and II would have altered the habitats of large game animals and may have reduced carrying capacity overall. At the very least, the geographic separation of resources would have been greater than at present.

FAUNA

Wildlife in the area has suffered a number of severe impacts from Euroamerican settlement including the eradication from the sample area of antelope (*Antilocarpa americana*), mountain sheep (*Ovis canadensis*), elk (*Cervus elaphus*), anadromous fish, wolf (*Canis lupus*), and river mussels (*Margaritifera falcata*), and great reduction in the variety of fur bearing animals, birds and amphibians. Nevertheless, the wildlife populations here have been less severely affected than in most areas of the United States. Baseline wildlife studies in the area have concentrated mainly upon deer and fish. For economic modeling, such attributes as season of availability, weight of resource individuals, available biomass, carrying capacity, and aggregate time/size/location are important considerations.

Fish

Although the results of contemporary fish studies may have little direct bearing on prehistoric resources in the study area, some historical data relevant to the availability of anadromous fish in the Columbia River system do exist (Craig and Hacker 1940; Bureau of Reclamation 1947, 1976; Fulton 1968, 1970; Fish Commission of Oregon, and Washington Department of Fisheries 1971; USACE 1975; Chaney and Perry 1976; Carl, Clemens, and Lindsey 1977; Erickson 1980). Species of major economic interest which were either resident or passed through the study area prior to the construction of Chief Joseph Dam, include resident trout (*Salmo* spp.), sucker (*Catostomus* spp.), whitefish (*Prosopium williamsoni*), steelhead (*S. gairdneri*), sturgeon (*Acipenser transmontanus*), and the salmons -- chinook (king) (*Oncorhynchus tschawytscha*), silver (coho) (*O. kisutch*), chum (dog) (*O. keta*), and lesser numbers of sockeye (*O. nerka*). While the time of runs has changed since the damming of the Columbia River, run times relevant to pre-contact periods are suggested by Ray (1932) as shown in Table 1-3.

Average weight, biomass, and densities of the resident fishes cannot be ascertained from available fisheries studies of the present Rufus Woods Reservoir, nor can we directly quantify the changing availability or density of the various runs over a six month period. We can, however, estimate the minimum number of fish available from records of annual Columbia River fish catches. The Corps of Engineers (USACE 1975) follows the Bureau of Reclamation (1947) in estimating an annual salmon biomass of 18,000,000 pounds (8,165,000 kg) and estimates that 10% would have been available in the study area before Euroamerican settlement. The five-year average annual catch of

Table 1-3. Seasonal availability of Columbia River fish in the study region.

Common Name	Latin Name	Time of Run	Weight (lbs)
Trout	*Salmo* spp.	Resident	—
Sucker	*Catostomus* spp.	Resident	—
Whitefish	*Prosopium williamsoni*	Resident	—
Steelhead	*Salmo gairdneri*	March to July	9[3]
Sturgeon	*Acipenser transmontanus*	August?	—
Chinook	*Oncorhynchus tschawytscha*	Late May to July[1]	25[1,3]
Silver (coho)	*O. kisutch*	Late Aug. to Late Nov.[1]	10[3]
Chum (dog)	*O. keta*	Late Aug. to Late Nov.[1]	11[3]
Sockeye	*O. nerka*	June to Sept.	3.5-8.0[2]

1. Ray 1932
2. Carl et al. 1977
3. Bureau of Reclamation 1976

Table 1-4. Average annual catch of Columbia River salmon by 5-year periods, 1866-1940 (Bureau of Reclamation 1947, reported in Bureau of Reclamation 1976:Table 10).

Period	(Thousands of pounds)					Total
	Chinook	Blueback	Silver	Chum	Steelhead	
1866-70	3,264					3,264
1871-75	14,348					14,348
1876-80	25,024					25,024
1881-85	31,493					31,493
1886-90	20,998					20,998
1891-95	24,248	2,371	2,986[2/]	844[3/]	3,662	34,111
1899-1900	23,257	1,819	3,330	988[4/]	2,104	31,498
1901-05	28,941[1/]	784	1,374[2/]	1,138[1/]	604[1/]	32,841
1906-10	23,282	723	2,934	2,154	623	29,717
1911-15	26,982	899	3,472	3,010	1,899	36,262
1916-20	30,437	809	4,519	3,476	1,980	41,221
1921-25	22,014	1,198	6,237	2,077	2,393	33,919
1926-30	20,326	725	5,995	3,975	2,885	33,906
1931-35	18,192	299	4,279	1,158	1,781	25,709
1936-40	16,181	382[5/]	4,190	1,396	1,908	24,557

[1/] Average for 4 years. There are no pack data for 1901.

[2/] Average of 4 years. There are no data for 1891 and 1901.

[3/] Figures for 1893 and 1895 only.

[4/] Figures for 1899 and 1900 only.

[5/] Excluding Quinault River bluebacks canned on Columbia River.[3/]

chinook alone between 1881 and 1885, however, is almost double that figure, at 31,493,000 pounds (14,285,000 kg), and the combined annual commercial catch of chinook, silver, chum, and steelhead during the period 1916-1920 averaged 41,221,000 pounds (18,698,000 kg) (Table 1-4). Moreover, these figures include only the commercial catch of the lower 100 miles (62 km) of the Columbia main stem, exclusive of white and Indian commercial and sport fisheries above the main stem and of open ocean fishing. Chaney and Perry (1976) estimate that 5,000,000 pounds (2,268,000 kg) of spring and summer chinook entered the commercial catch yearly from the area above the present Grand Coulee Dam. Thus at least 5,000,000 pounds (2,268,000 kg) of chinook and other anadromous species passed through the study area annually. Adding this figure to the peak production figures for 1916-1920, we estimate that at least 45,412,000 pounds (20,599,000 kg) of fish entered the Columbia River annually.

Whether this figure is above, below, or near the actual carrying capacity would appear to be irrelevant to hunter-gatherer economies. Anadromous fish stocks of the Columbia system began to diminish radically only after loss of spawning beds (due to siltation with increased erosion and runoff due to placer mining, logging, and farming) and the combined efforts of commercial and sport fishing throughout the system from 1866 to 1930 (including gill netting at the mouth, open ocean netting, and fish wheels). Increase in the intensity of a fishery will deplete stocks only if it becomes so great that it reduces the spawning escapement to below the level providing the maximum yield, and it appears doubtful that within-river fishing, even at maximum intensity, was a direct cause of depletion from the 1930s to the 1950s (Bureau of Reclamation 1976:11-28).

As abundant as this resource apparently was before white settlement, it does not appear to represent a potential economy of scale, one whose return varies directly with increasing effort. Rather it is dependent upon technology. The reason for this becomes apparent when one attempts to estimate the density and aggregation of salmon in the study area. Taking 5,000,000 pounds (2,268,000 kg) as a minumum biomass, and estimating the average weight of the combined species available at 17.1 pounds (7.76 kg) (weight/number of commercial fish catches -- Bureau of Reclamation 1976:Table 12), at least 290,000 fish passed through the study area annually during the six months of runs. While daily as well as weekly and monthly numbers passing any one point along the river would have varied widely, we can grossly approximate the average density by dividing the annual count by the 184 days in the fishing season (ca. March-October), obtaining 1,589.1 fish per day. Supposing that the fish, on average, travel 10 km per day, and that the average width of the river in the study area is 0.1 km, then the estimated density of fish is 1,589.1 fish per km^2, or almost 16 fish per hectare, an impressive biomass compared to that of most habitats. If these numbers are anywhere near correct, however, only about 65 fish would pass any one point per hour across the width of the river.

Geographically, the anadromous fish are restricted to Zone I, since falls block runs up Coyote Creek, the Nespelem River, and lesser streams in the sample area. These lateral drainages contain trout and other resident fishes, as do the lakes in Zone III. While these should be obtainable at any season, the biomass and cost-benefit of exploitation have yet to be determined. The anadromous fish in Zone I represent a rich and secure resource for the five or so months of heavy runs, but without gill nets and seines to effectively exploit the main channel of the river at the wide reaches, high productivity would be limited by the availability of rapids, channel constrictions, falls, and entrances to shallow feeder streams. Although the carrying capacity is unlikely ever to have been approached, the return-for-effect margin should vary inversely with increasing human population at high density points along the river. Hypothetically, since anadromous fish are available in quantity only half the year, the proportion of fish in a foraging subsistence base could not much exceed 0.5, while the proportion in a collecting system with effective techniques of harvesting, preservation, and storage could approach 1.0 with low regional population and low aggregation (the important question of the nutrient profile of dried fish aside). Such a collecting system would be sedentary, with loci of habitation clustered at good fishing spots along the river. Whether due to nutritional inadequacies of a diet consisting primarily of fish, or to diminishing cost-benefit margins of fishing in response to population pressure, any significant exploitation of vegetable or land mammal resources would necessitate conversion to a central-based system.

Artiodactyls

The biomass, distribution, and carrying capacity of artiodactyls is an important consideration in modeling human subsistence patterns. While deer, elk, antelope, mountain sheep, and, infrequently, bison are known to have been exploited in the study area archaeologically (Lyman 1978), only mule deer (Odocoileus hemionus) are common today. The relative abundance of deer and other mammal species is shown in Table 1-5. As of 1974-75, 431 mule deer were estimated to inhabit the study area. Of these, 12% were resident in Zone I and 88% wintered in Zones I and II, migrating to the uplands in spring (Erickson et al. 1977:4). The reproductive success of the herd was estimated at 33%, and the late fall profile consisted of 12% bucks, 65% does, and 23% fawns. The 0.23 recruitment rate and low reproductive success would suggest a herd approaching subsistence density (Smith 1975:24) despite a long hunting season on the Colville Reservation. Contributing factors, doubtless, are loss of winter habitat in Zone I and apparent competition with cattle in some habitats (Erickson et al. 1977:221).

The question of herd density and aggregation size is complex, for these vary with respect to season, zone, intrazonal geography, and habitat type. It should be recognized that Erickson et al. used both direct observation and calculation from pellet group data to estimate herd densities, and the results are often in conflict. Secondly, their primary area of concern was Zone I, and they employed only pellet group sampling along tracts in Zone IIIR as a control. The average number of deer observed per survey declined from 15.8 in August to 1.0 in December, but climbed from 60.0 in January to a peak of 151.7 in February, dropped to 45.0 in March, and dwindled in 11.5 in June (Erickson et al. 1977:179). The observations, unfortunately, were not converted to

Table 1-5. Relative abundance and seasonal status of mammal species identified in Zone I of the study region (from Erickson et al. 1977:Table 8.2).

Resident Species		Relative abundance[1]	Seasonality[2]
Common Name	Scientific Name		
Yellow-billed marmot	*(Marmota flaviventrii)*	Common	Resident
Least chipmunk	*(Eutamias minimus)*	Rare	Resident
Yellow pine chipmunk	*(Eutamias amoenus)*	Rare	Resident
Northern pocket gopher	*(Thomomys talpoides)*	Common	Resident
Great Basin pocket mouse	*(Perognathus parvus)*	Abundant	Resident
Western harvest mouse	*(Reithrodontomys megalotis)*	Rare	Resident
Bushy-tailed wood rat	*(Neotoma cinerea)*	Common	Resident
Deer mouse	*(Peromyscus maniculatus)*	Abundant	Resident
Sagebrush meadow mouse	*(Lagurus curtatus)*	Common	Resident
Muskrat	*(Ondatra zibethica)*	Rare	Resident
House mouse	*(Mus musculus)*	Rare	Resident
Montane meadow mouse	*(Microtus montanus)*	Common	Resident
Beaver	*(Castor canadensis)*	Rare	Resident
Porcupine	*(Erethizon dorsatum)*	Common	Resident
White-tailed hare	*(Lepus townsendii*	Rare	Resident
Nuttall cottontail	*(Sylvilagus nuttallii)*	Common	Resident
Shrew	*(Sorex sp.)*	Rare	Resident
Coyote	*(Canis latrans)*	Abundant	Resident
Black bear	*(Ursus americanus)*	Rare	Visitor
Raccoon	*(Procvon lotor)*	Common	Resident
Wolverine	*(Gulo luscus)*	Rare	Visitor
Badger	*(Taxidea taxus)*	Rare	Resident
Striped skunk	*(Mephitis mephitis)*	Rare	Resident
Bobcat	*(Lynx rufus)*	Common	Resident
Mule deer	*(Odocoileus hemionus)*	Abundant	Resident & Local migrant
White-tailed deer	*(Odocoileus virginianus)*	Rare	Local migrant
Moose	*(Alces alces)*	Rare	Visitor
Bat	*(Myotis sp.)*	Common	Resident

[1] Abundance rating: Abundant = frequently recorded; Common = regularly recorded in low abundance; Rare = infrequent records.

[2] Seasonality: Resident = year-long presence in study area; Local Migrant = seasonal in-migrant; Visitor = occasional occurrence.

densities. Pellet group data in Zone III, however, indicates high densities in both late summer/fall (August through December) and winter (January through March) with a radical dropoff in spring/early summer (April-July). Erickson et al. explain the discrepancy in the fall data by positing avoidance behavior due to the hunting season, so that deer defecated but were not seen, so to speak. Considering just pellet counts, however, the relative densities in Zones I and IIIR for the three seasons appear to be contradictory (Table 1-6). The high density in Zone IIIR in August-December could be explained by a low density at the same season in Zone I. If this is the case, herd movements and shifting densities are fairly clear. Highest densities occur in Zone I and perhaps in protected draws and canyons in Zone II during the winter, most of the deer having been driven down from the uplands by cold and snow accumulation. January to March is also the time of greatest group size. While the average group size is 3.7 for the entire year, the averages climb from 2.0 in December to a peak of 6.7 in February. While the herd in the study area is clearly never very social, the greatest density and aggregation certainly occur in Zone I during the winter months.

Table 1-6. Density of deer per km^2 as determined from pellet group counts (from Erickson et al. 1977).

Zone	Season		
	Aug-Dec	Jan-Mar	Apr-July
Zone *IL*	6.2	5.7	0.7
Zone *IIIR*	9.9	2.5	2.5

Within Zone I and presumably Zone II there is considerable difference in preferred habitat. While the greatest percentages of deer observed or calculated by pellet group data occur in the sage-steppe habitat (SS), this habitat accounts for most of the acreage in Zone I. When calculated as density per habitat unit area, densities are considerably higher in the microhabitats other than shrub-steppe, although habitat preferences appear to vary by season (Figure 1-12). Intrazonally, and apparently independent of habitat preference, over 80% of the deer observed were sighted on the south side of the reservoir (Zone IL), and the highest densities were observed around River Miles 581, 567, and 552, though here again density varied by season.

While biomass is a measure of total amount of some resource in unit numbers, weights, or kilocalories per some unit of space, carrying capacity is that portion which can be subtracted from the breeding population (or seed population) without significantly altering the total biomass. Carrying capacity can be considered to be synonymous with recruitment, the number of individuals added yearly to the breeding stock after the initial subtractions

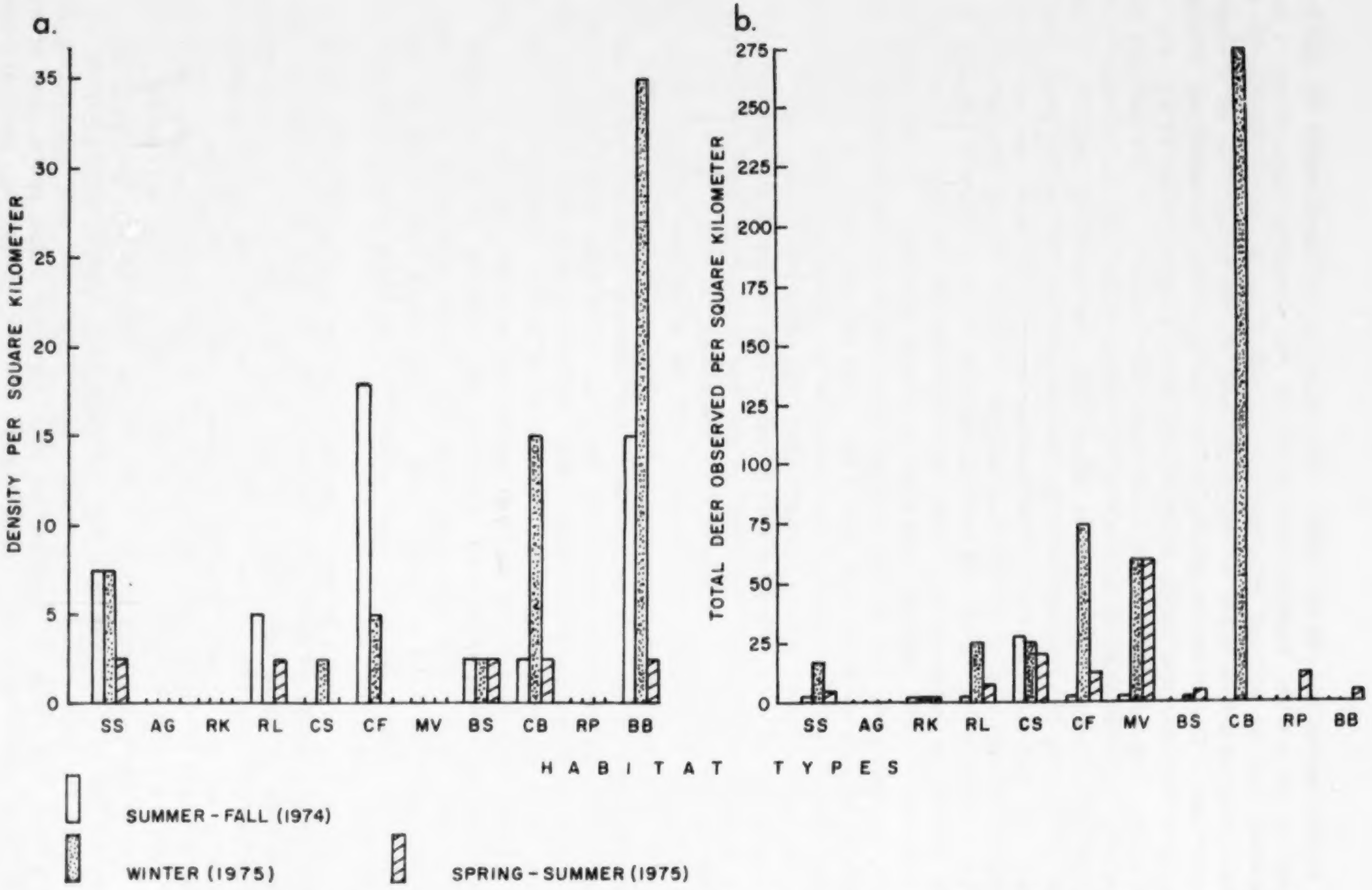


Figure 1-12. Seasonal habitat preference of mule deer in study area as determined from pellet group counts (a) and from river surveys (b) from Erickson et al. 1977:Figures 8.14 and 8.15).

of infant mortality (Smith 1975). The relation of recruitment to carrying capacity, of course, depends much upon how the breeding population is being predated, but we can use this concept to calculate an approximation of the potential productive yield of the deer herd in the study area as presently constituted. The wildlife biologist of the Colville Confederated Tribes suggests that average bucks weigh 90 kg (live weight), does 68 kg, and yearlings 1 kg. Since the herd, at least for Zones I, II and perhaps part of Zone III, is estimated to consist of 431 members and the recruitment rate (percentage of yearling fawns) is about 20%, the carrying capacity is about 86 deer. Breaking this number down by the proportions of bucks, does, and yearlings, and multiplying by the average weights of each, we can express the carrying capacity as 5,550 kg live weight of deer. While dressed weight is normally considered to be 50% of live weight, this proportion depends entirely upon dietary preference, and total nutrient content probably is as high as 75% if internal organs, marrow, and even skin are consumed. In any case, if the yield is separated into elements used (nutitional and technological), waste products may constitute less than 15%. Live weight, then, is a fair approximation of the value of the resource to hunter-gatherer populations.

As can be seen, if the present carrying capacity in any way approximates that in the prehistoric past, deer alone could not account for a very large proportion of the diet unless the population were relatively small. As far as artiodactyls in general are concerned, we must add to this figure the biomass of antelope, elk, sheep, and the occasional bison. Bison (Bison bison) are thought to have become extinct in the region as early as 2000 B.P. (Osborne 1953) or as late as the mid-18th century (Schroedl 1973) and even before their extinction apparently could not have been plentiful in the Plateau region (Daubenmire 1970). Ray (1932) suggests that antelope were hunted only in Zones II and IIIL in the study area. Antelope and deer were not usually competitors so their biomass can be added to the total. Sources approximating antelope density, weights, and behavior in an analogous environment have not as yet been obtained. Sheep apparently would have grazed the Rock (RK) habitats of Zones I and II, and would have competed less than cattle with deer. The only major competitor to sheep would have been elk in Zones IIIR and IV.

While the biomass of each species might be approximated by recourse to documented studies of analogous environments, it must be remembered that the interaction of these components is specific to a particular environment. The principal limiting factor in the study area is the carrying capacity of winter graze and browse species in Zones I and II. While the total biomass of large game may have been larger before European settlement, all factors point to Zone I or II as the primary winter settlement location for hunter-gatherer populations. All things considered, the carrying capacity for all artiodactyls may not have been significantly higher than that for deer today. The modern environment and deer population probably are within the range of fluctuation over the last 5,000 years, and deer could never have supported a very large group, whether wandering, central-based, or sedentary.

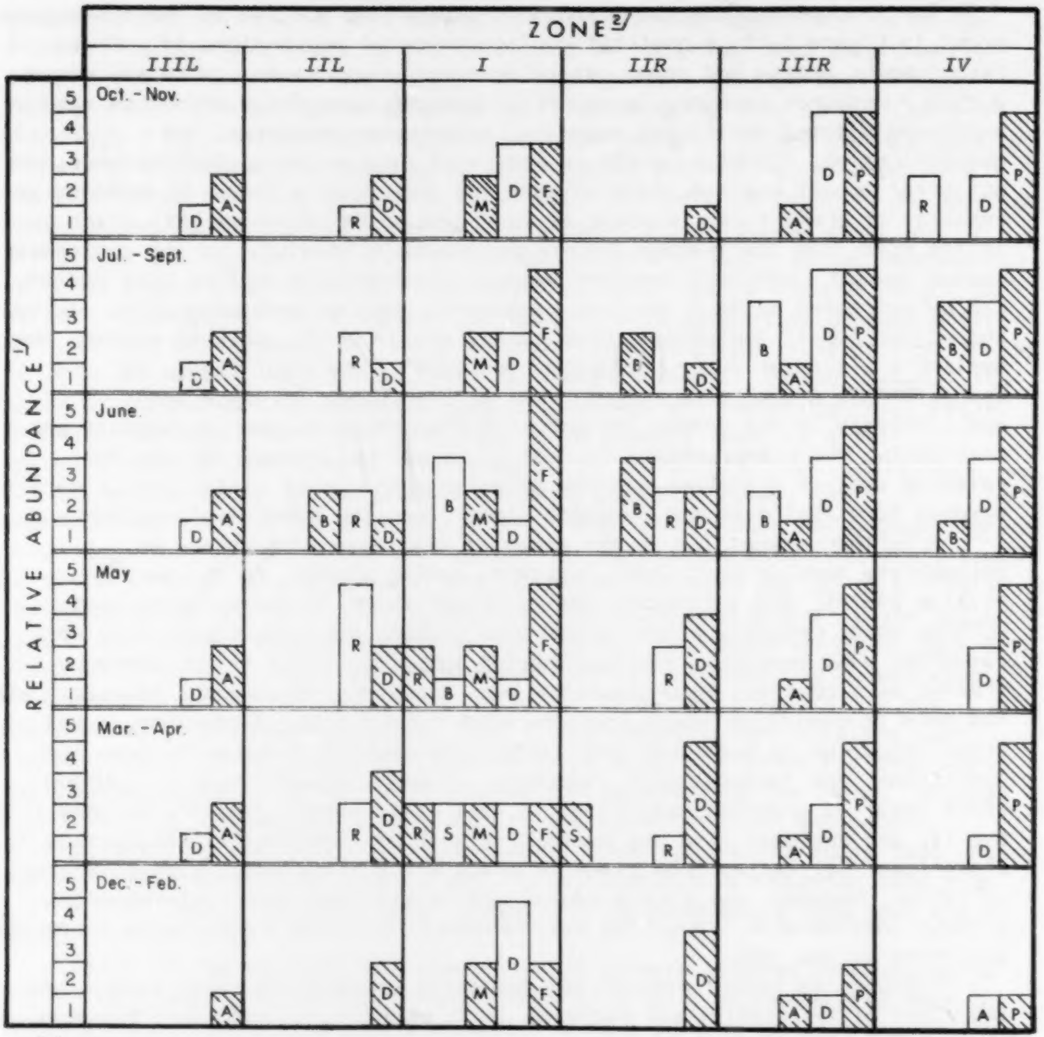
THE MODEL AND EXPECTATIONS

The information discussed above is summarized roughly by the time/space model in Figure 1-13, a qualitative impression of proportions of various resources by season and zone. While changing proportions can be expressed *within* a resource category, proportions *between* categories cannot be easily expressed without additional sampling, documentary research, and quantification. Given a random selection of herd animals, for instance, the potential annual average yield of deer for Zone I as a whole if predated up to capacity at present levels would be 79.75 pounds/km^2 live weight, which is little more than one average animal per square kilometer. In the spring-early summer season, only 0.74 deer per square kilometer, or 47.8 kg live weight, can be extracted without seriously depleting the resident community. In fall and winter (or if the pellet group counts are in error, only in winter) the available yield per square kilometer increases some eight times, to approximately 400 kg live weight. While this change is expressed qualitatively in the graph, the relative proportion of deer to mussels and fish during the winter months in Zone I, is not yet known, nor are the relative ease of predation and the relative nutritional yield. It is merely assumed here that deer are somewhat higher than the other two combined.

A further assumption is the array of available resources. We concentrate here on fish, deer, mussels, spring shoots, roots, berries, aquatic plants, and a category called "pine" which includes forest products such as wood, cambium, pitch, black tree lichen, and some winter-available resources like bearberry (*Arctostaphylos uva-ursi*). The "pine" category is treated as a constant throughout the year except in January and February, when the snow accumulation would increase effort for yield. Altogether, a set of three resources is available year round, representing a security base for nutritional and technological resources: aquatic plants (rushes, cattail), which occur in greatest quantities in Zone IIIL, forest products in Zone IIIR and IV, and resident fish and mussels in Zone I. The spatial disjunction is significant but varies from place to place along the river. Even given the variation, however, one simply cannot get to all three sorts of resources without considerable travelling and transport is always required to assemble all three in one spot.

Although we cannot make direct abundance comparisons among categories, the model of the spatial and temporal distributions of important resources presented in Figure 1-13 does give us a basis for considering the nature of hunter-gatherer adaptations possible in the study area.

A foraging system with a minimal requirement for construction materials and no storage techniques or facilities other than those naturally provided by winter temperatures, could, apparently, adapt to the study area under the conditions shown in Figure 1-13, given a very low regional and aggregate population. The only viable settlement location in winter is in Zone I or in the lower reaches of the canyons in Zone IIR. While the deer density would be higher in Zone I, the trip distance to forest products (P) would be increased. If even a few bison were involved in winter biomass in Zone I, the potential for winter habitation in Zone I would be increased. The foraging peoples



1/ Relative Abundance: 1 = Very Low· 2 = Low; 3 = Medium; 4 = High: 5 = Very High.

2/ A = Aquatic Plants; B = Berry; D = Deer; F = Fish; M = Mussel; P = Pine; R = Root; S = Shoot.

Figure 1-13. Hypothetical time-space distribution for availability of selected subsistence resources.

would have more choices after winter. In March-April the deer are moving toward the uplands, and the resources in Zone I are at their lowest ebb. A movement to Zone II in March-April, when the roots offer their greatest yield, is indicated, although a simple relocation in Zone I to fresh sources of fish and mussels and the few available roots and shoots also seems possible. The outputs and locations for each of the latter alternatives are distinct and need not be belabored here. Throughout the rest of the year, the advantage of the riparian habitat in Zone I is obvious; from the standpoint of biomass and predictability of location, the anadromous fish should exert a strong pull in favor of Zone I. If this is the case, the likelihood of any "big game" adaptation seems small.

While a general foraging system with a settlement network almost wholly restricted to Zone I appears to be possible, the question of population levels and resource depletion looms large. The only apparent way to extend the resource base beyond modest levels would be to provide for winter storage and to split community effort during spring, summer, and fall to take advantage of spatially disjunct resources. We would expect, then, a very early shift in the region to a logistical system, with an attendant increased requirement for wood products for building winter dwellings, fishing platforms, storage facilities, drying racks, and the like and for smoking meat. Increased need of wood suggests clustering of activity loci almost entirely within the central portion of the study area, where trip distance to the forests in Zones IIIR and IV is minimized.

A sedentary logistical system also seems a possibility. Such a system at some period would imply hamlet-sized habitation sites clustered near rapids or other fishing spotes and few, if any, secondary logistical camps outside Zones I and II. Dependence on resources other than fish, however, would require greater extension into upland zones. At this point, the distinction between sedentary and central-based systems becomes one of degree. Whether they could be distinguished from one another remains to be seen.

ETHNOGRAPHY AND ACTIVITY CHAIN ANALYSIS

We begin the model building process by assuming as a working hypothesis the truth of the ethnographic information about cultural activities in the study area in historic and protohistoric times. We propose to follow a primary research strategy of inference from an ethnographic model to describe recent prehistoric systems, and a course of progressive modifications of that model to specify earlier system states. Activity chain analysis provides a method for organizing and assessing information and assembling a descriptive model of the resource base, qualitative material outputs, and output locations. These, in conjunction with recent environmental studies, provide a basis for estimating the resource base and for eventual construction of simulations to estimate quantitative material outputs.

The advantage of working in a region where hunter-gatherer systems persisted until Euroamerican contact and in a study area provided with detailed ethnographic records cannot be overstated. The flora and fauna of any region are so diverse that there is no sure way to decide which elements were critical parts of the prehistoric resource base. The choice of resource variables could be evaluated in the testing phase of research. Economic modeling, however, involves so many assumptions at so many critical junctures that one cannot be certain whether a fault lies simply with the environmental parameters employed or with the decision model itself. Moreover, as stated previously, expectations from economic models tend to articulate poorly with actual archaeological observations. While working with ethnographic observations presents a multitude of pitfalls, accounts of residents are more likely to reflect the full resource potential of the study area than analogies to distant areas argued by researchers with only a passing and urbane knowledge of the environment. In the following pages we discuss the scope and applicability of ethnographic sources, summarize the methods of activity chain analysis, and present examples of analyses to demonstrate their feasibility and utility.

ETHNOGRAPHY

The primary ethnographic sources for the study area are Ray's (1932) study of the Sanpoil and Nespelem--the peoples occupying the north and south of the Columbia River from above the Spokane River west to the Omak Trench--and Spier's (1938) study of the Southern Okanogan, or Sinkaietk--the peoples occupying the Columbia and Okanogan Rivers west of the Omak Trench. The ethnographies were intended to provide the best possible portrait of aboriginal life before the changes attendant on the coming of the horse, the gun, and other aspects of Euroamerican culture. The volumes follow similar formats and include chapters on linguistics, cultural affiliation, settlement, population and territory, daily and yearly patterns of activity, social structure, life cycles, mythology and ritual behavior, and material culture associated with subsistence practices. Regional summaries, ethnohistories, and ethnogeographies (Teit 1930; Spier 1936; Ray 1936, 1945, 1975; Lee 1967; Chance 1973; Chalfant 1974; Kennedy and Bouchard 1975; Bouchard and Kennedy 1979) provide useful supplementary information. Recent ethnobotanies of the area contain botanical identifications of plants used for food and technological purposes as well as additional information on cultural activities associated with their collection and preparation (Turner, Bouchard, and Kennedy 1977; Turner 1978, 1979). There are a variety of historical documents containing useful information (e.g., Thompson 1811; Work 1823; Warre and Vavasour 1845; Schoolcraft 1851; Thwaites 1905; Ermatinger 1912; Douglass 1914; Lewis 1925; Cox 1957; Glover 1962; Merk 1968). Of particular importance to this study would be the examination of Northwest Fur Company and Hudson's Bay Company records for weights and counts of hides, meat, and other economic products.

As Thomas (1973:156) points out, the information contained in these primary and secondary sources is not, for the most part, "facts" about the past. While some field observations are embedded in the accounts, Ray and Spier queried informants about lifeways ostensibly as they were before contact with Euroamerican culture. The ethnographic narratives are presented in the "historical present" tense, and the arrangement of information, reconciliation of contradictions, and evaluation of credibility and historical accuracy are performed behind the scenes. Thus, the ethnographic records constitute an historical "hypothesis" which is, to some extent, archaeologically testable. It should be noted that our purpose here is not to test either the acuity of the ethnographers or the veracity of the informants. There are sure to be some glaring discrepancies between the ethnographic model and archaeological data, even for the protohistoric period. The ethnographic models are viewed as working hypotheses to be tested, modified, and retested against the data for each chronological period. In many respects, the failures of the model are more important than fulfilled expectations, for it is by successive modifications of the model that descriptions for earlier system types are built.

In using such ethnographic documents, it is important to ask whether the assertions of the informants relate in any way to the prehistoric context. To investigate this question we can graphically display the information pathways of informants in relation to a few of the major system variables in operation during the historic period (Figure 1-14). It is assumed that parents (P), grandparents (PP), and great-grandparents (PPP) of informants were, on the average, about 30 years old at the birth of the next generation; the first ten years of each group's lifespan have been blocked out, since we assume that little reliable information could have been passed from generation to generation during this time. A variety of primary and secondary sources estimate Native American population levels during the protohistoric period (Bouchard and Kennedy 1979), and the estimates are variable. We have chosen to use Lee's (1967) estimates for the "Colville" and Ray's (1932) estimates for the Sanpoil-Nespelem as being typical of these data. Although they differ in absolute numbers and rate of change, these estimates clearly show a relationship between depopulation and disease epidemics in the late eighteenth and middle nineteenth centuries. The population curve for fur-bearing mammals is purely conjectural, but we do know that they were close to extinction by the 1830s. We can also assume that mountain sheep, antelope, and elk probably disappeared from the area during this time. The plot of average annual chinook salmon catch indicates a cycle of depletion and recovery from about 1890 to 1930. Radical depletion apparently occurred only after the 1930s.

Just how old are the traditions passed on to the informants? One indication, perhaps, is that while the use of stone tools is often mentioned in the literature, none of the informants recall anything of their manufacture; yet metal tools could not have replaced the traditional materials much before the late eighteenth century, and the shift to metal was more likely to have occurred during the period of the fur trade. Much of the information gathered by the ethnographers, then, evidently refers to the actual experience of the informants themselves or to the experiences of parents and grandparents during the period from 1830 to 1890. The oldest informants, and the parents of the younger informants, would recall a time before placer mining, sheep and cattle grazing, logging, and the Euroamerican fishery. Vegetable resources would virtually have been unchanged, and the biomass of anadromous fish, given the drop in native

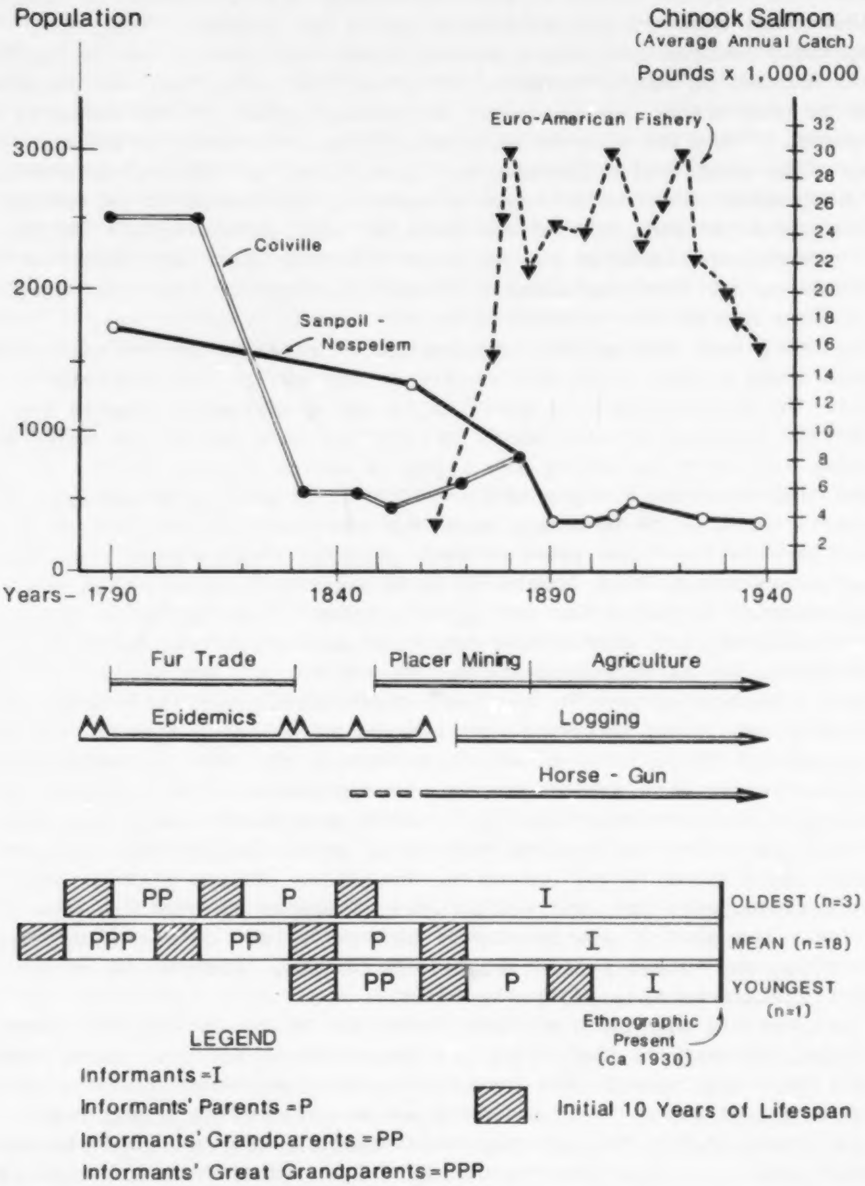


Figure 1-14. Relationship between ages of Native American informants and major historical trends.

population, might have been somewhat higher than in earlier centuries, but some species of mammals should have been depleted. One might expect, therefore, a high proportion of fish in the diet, a lower proportion of vegetable foods, and a very low proportion of deer. While neither Ray nor Spier and associates could make quantitative assessments, their estimates of the proportions of fish, game and vegetable foods are informative.

> Hunting definitely took a second place as compared to fishing as an economically important activity. Game was perhaps roughly equivalent, quantitatively, to roots and berries in the diet of the group (Ray 1932:77).

> It is difficult at this late date to estimate the proportions used of different foods. There was variation from band to band, from family to family, and from year to year. Some of the families, spending much time at the fishing rounds, would take enough salmon to last almost the year around, and the few who stayed in the hills subsisted very largely on deer. To judge from the mention of foods in tales and anecdotes, I should estimate that approximately equal thirds were used of game, of fish, and vegetable foods, but close questioning brings up the vegetable quota to one-half. Undoubtedly the Indians preferred fish and game to the latter, and particularly deer meat. Probably more salmon was eaten than deer meat. Small game and smaller fish played a very minor role, and none were preserved but suckers.
>
> Chilowist Jim stated that some twenty salmon were stored in a single tule sack. Each family had about ten sacks of these and as many of deer meat. About equal amounts of deer and salmon were used. All these sacks containing a family's winter food supply made a pile six feet tall.
>
> Johnnie stated that fresh deer meat was preferred to all other food. The Southern Okanogan ate four or five times as much salmon as game during the year. The Colville took enough salmon, largely at Kettle Falls, to last them the year around, but few others did (Spier 1938:12).

While Spier suggests that the diet included greater amounts of vegetable foods than either fish or deer, Ray suggests more salmon than vegetable foods or deer (and equal proportions of the latter). These estimated proportions of vegetable products in the economy run somewhat counter to general archaeological opinion about the reliance on fish, and the reported proportions of deer to fish and deer to vegetable foods seem considerably higher than expected and may reflect both the low population levels and an extensive hunting territory opened up by use of the horse. All told, the suggestion is one of considerable local variability in diet and (except for little mention of antelope, elk, or mountain sheep) no evidence of a devastated environment.

ACTIVITY CHAIN ANALYSIS

While Schiffer has drawn on earlier sources (e.g., Krause and Thorne 1971) in the development of the methodology of behavioral chain analysis, his is certainly the most detailed, accessible, and archaeologically relevant formulation (1975, 1976:49-54). An activity chain is a type of transformation model used here to systematize narratively organized ethnographic information. The focus of the analysis is on activity, which we follow Schiffer in defining as, "the interaction between at least one energy source and one cultural element" (1976:45). An activity chain is the sequence of activities in which an element (artifact or actor) participates within the systemic context. It models the pathway from system operation to archaeological output. Outputs and output locatons are test implications of the ethnographic hypothesis. The chain models may be expressed either as tables or as flow models, the former best suited to working from the raw ethnographic information and the latter best suited to expressing output clusters, modeling pathway intersections, and organizing variables for possible simulation modeling.

The cultural system being modeled is a continuous cycling of human actions with respect to units of space and time, closed with respect to the pattern of repetitive activities, and open with respect to inputs of energy and materials and outputs of transformed materials. While the entire network of activity pathways is closed, it must be broken into linear segments for didactic purposes and for analytic convenience. In the following pages we present, as examples, four sets of analytic sequences -- hunting, plant utilization, fishing and lithic manufacture (Tables 1-7 through 1-12).

The form of these tables requires some discussion. Each table represents an activity sequence. Each row is a segment of that sequence, and columns represent components of segments. The first component describes an action, or suite of actions, normally expressed by a verb and an object acted upon (e.g., "shoot deer"). Descriptors such as "travel" group a potentially immense number of actions, only a few of which are liable to have left recoverable outputs. Others, such as "erect mat hut," summarize separate and distinct activity chains, analyzed in detail elsewhere, which intersect the main sequence. The components location, time, and energy sources specify the physiographic zone in which each action takes place, the associated habitat types, the season and/or duration of the action, and the actors. At this point, our analysis departs significantly from Schiffer's example (1976:Figure 4.4). Our component conjoined elements includes all artifacts, other than the object acted upon, which are involved in the action described. Schiffer's category "intersections" is omitted. Our component outputs does not include artifacts such as non-charred wood chips which are not likely to have survived, given soil conditions in the study area. It does, however, include broken or abandoned tools, which only occasionally result from a given action. We have not attempted to deal here with questions of refuse transport, use life, curation behavior, recycling, or lateral cycling. These must be dealt with later in analysis. The final component activity

Table 1-7. Activity chain model for Sanpoil-Nespelem extended deer hunting trip (see bottom of table for key).

DEER HUNTING: EXTENDED TRIP	LOCATION		TIME	ENERGY SOURCES	CONJOINED ELEMENTS	OUTPUTS	ACTIVITY AREA
	ZONE	*HABITAT*					
Prepare for hunt. Sweat [1].	Terrace, Zone *I*.		Nov.-March, twice daily for 10 days before hunt [1].	7-8 men of hunting group [1], fire.	Fuel, rocks, wooden tongs [1].	Fire-cracked rock (811), burnt soil (810), charred wood (701), unmodified cobbles (301).	Hearth outside sweat lodge, winter village.
Repair moccasins, bows, arrows, mats, baskets, storage bags, sleeping robes, ±snowshoes [1].	Terrace, Zone *I*.		Nov.-March, before hunting trip [1].	10-12 members of hunting group, fire.	Cutting, piercing, abrading, pressure flaking implements, glue, sinew, feathers, patches, thread, fuel.	Broken/abandoned cutting (101, 102), piercing (107), abrading (116), pressure flaking (120) implements, charred wood (701), fire-cracked rock (811), burnt soil (810), lithic debitage (199).	Hearth area in or near dwelling, winter village.
Pack bows, arrows, fire drills, baskets, mats, bags, sleeping robes, tools, dried fish [1].	Terrace, Zone *I*.		Nov.-March, before hunting trip [1].	10-12 members of hunting group.	Tumpline [1].		
Travel from winter village to hunt camp [1].	Terrace, Zone *I* to Zone *III*, *IV*.		Nov.-March, 1-3 days [1].	10-12 members of hunting group.	±Snowshoes, packs as above, ±temporary shelter, fuel.	Small amount fire-cracked rock (811), burnt soil (810), charred wood (701), ±unmodified cobbles (301).	Hearth, travel camp.
Erect temporary mat huts [1].	Foot of draw, Zone *III*, *IV*.	In or near BS, CB.	Nov.-March, less than one day.	3-4 women of hunting group [1].	Poles, mats [1], cutting, chopping, wedging, pounding implements, lashing material.	Broken/abandoned cutting (101), chopping (104), wedging (117), pounding (115) implements, lithic debitage (199).	Hunt camp.
Hunt. Drive deer [1].	Foot of draw to head, Zone *III*, *IV*.	BS, CB.	Nov.-March, ±daily during trip.	4-5 men of hunting group [1], ±dogs [2]?	±Snowshoes.		
Shoot deer [1].	Head of draw, Zone *III*, *IV*.	In or near BS, CB.	Nov.-March, ±daily during trip.	2-3 men of hunting group [1].	Bows, arrows [1], ±snowshoes.	A few whole and broken projectile points (201, 202).	Dispersed, head of draw.
Skin and butcher deer. ±Skin and cut up deer (large kill) [1, 3]; extract brains for use in skin dressing [1].	±Head of draw, Zone *III*, *IV*.	In or near BS, CB.	Nov.-March, as needed.	7-8 men of hunting group [1, 3].	Cutting implements (stone knives, round or long blade [3]), chopping implements.	Broken projectile points (202), broken/abandoned cutting (101), chopping (104) implements, small amount bone (601), ±cranial bone (609), debitage (199).	Butchering area near kill site.
Transport ±meat, skin, bones (?), ±unbutchered deer [1, 3].	Head of draw to foot, Zone *III*, *IV*.	BS, CB.	Nov.-March, as needed.	7-8 men of hunting group [1, 3].	Tumpline, ±snowshoes [1, 3].		
±Skin and cut up deer (small kill) [1, 3]; extract brains for use in skin dressing [1].	Foot of draw, Zone *III*, *IV*.	In or near BS, CB.	Nov.-March, as needed.	7-8 men of hunting group [1, 3].	Cutting implements (stone knives, round or long blade [3]), chopping implements.	Broken projectile points (202), broken/abandoned cutting (101), chopping (104) implements, small amount bone (601), ±cranial bone (609), debitage (199).	Butchering area, hunt camp.
Cook and eat fresh meat. Cut up meat.	Foot of draw, Zone *III*, *IV*.	In or near BS, CB.	Nov.-March, as available.	3-4 women of hunting group [1].	Cutting implements (stone knives [3].	Broken/abandoned cutting implements (101), lithic debitage (199).	In or near hearth, hunt camp.
±Roast meat [1, 3].	Foot of draw, Zone *III*, *IV*.	In or near BS, CB.	Nov.-March, daily as available.	3-4 women of hunting group [1], fire.	Fuel, long thin sticks.	Fire-cracked rock (811), burnt soil (810), charred wood, not pine or juniper (702).	Hearth, hunt camp.

Table 1-7, cont'd.

DEER HUNTING: EXTENDED TRIP (cont.)	LOCATION		TIME	ENERGY SOURCES	CONJOINED ELEMENTS	OUTPUTS	ACTIVITY AREA
	ZONE	HABITAT					
?Boil meat [1, 3] and/or blood [1].	Foot of draw, Zone *III, IV*.	In or near BS, CB.	Nov.-March, daily as available.	3-4 women of hunting group [1], fire.	Fuel, ?cooking basket, ?small pit lined with deerskin, water, ?berries, rocks, wooden tongs [1].	Fire-cracked rock (811), burnt soil (810), charred wood (701), ?unmodified cobbles (301), ?small soil depression (803), ?seeds (704).	Hearth, hunt camp.
Eat fresh venison.	Foot of draw, Zone *III, IV*.	In or near BS, CB.	Nov.-March, daily as available [1].	10-12 members of hunting group.	Serving mats, ?cooking basket, ?wooden or horn spoon, ?sharp serving stick [1].	Broken/abandoned horn spoon (523).	Hunt camp.
?Eat boiled blood, drink raw blood [1].	Foot of draw, Zone *III, IV*.	In or near BS, CB.	Nov.-March, as desired and available.	7-8 men of hunting group only [1].	?Basket.		
?Extract and eat marrow [1].	Foot of draw, Zone *III, IV*.	In or near BS, CB.	Nov.-March, as desired and available.	10-12 members of hunting group.	Chopping, pounding implements.	Broken/abandoned chopping (104), pounding (115) implements, long bone splinters (604), lithic debitage (199).	In or near hearth, hunt camp.
Dry meat. Build drying rack ?wind screen [1].	Foot of draw, Zone *III, IV*.	In or near BS, CB.	Nov.-March, less than one day.	3-4 women of hunting group.	Cutting, chopping, pounding, wedging implements, willow poles [1], lashing material.	Broken/abandoned cutting (101), chopping (104), pounding (115), wedging (117) implements, lithic debitage (199), post molds (804).	Drying area, hunt camp.
Cut meat into thin strips; spread meat and bones on rack [1].	Foot of draw, Zone *III, IV*.	In or near BS, CB.	Nov.-March, as available.	3-4 women of hunting group [1].	Cutting implements.	Broken/abandoned cutting (101) implements.	Drying area, hunt camp.
Dry meat and bones [1].	Foot of draw, Zone *III, IV*.	In or near BS, CB.	Nov.-March, as available, 24-48 hours each batch [1].	3-4 women of hunting group [1], fire.	Willow [1] or other non-resinous fuel such as alder [5].	Large, rectangular area of burnt soil (810) and charred wood, not pine or juniper (702), ?fire-cracked rock (811).	Drying rack, drying area, hunt camp.
Strip bits of dry meat from bones [1].	Foot of draw, Zone *III, IV*.	In or near BS, CB.	Nov.-March, as meat dries.	3-4 women of hunting group [1].	Scraping implements.	Broken/abandoned scraping (106) implements, lithic debitage (199).	Drying area(?), hunt camp.
Deposit bones [1].	Foot of draw, Zone *III, IV*.	BS, CB, CT, CF.	Nov.-March, as meat is eaten or dried.	7-8 men of hunting group.	Piece of old tule mat [1].	Bones (601).	Bone deposit area (in trees [1]), near hunt camp.
Store dried meat. Pack dried meat [1] ?some long bones for later tool manufacture?	Foot of draw, Zone *III, IV*.	In or near BS, CB.	Nov.-March, as meat dries.	3-4 women of hunting group.	Large tule bags, piercing implement (needle [1]), thread [1].	Broken/abandoned piercing (107) implement.	Drying area, hunt camp.
Store (temporarily).	Foot of draw, Zone *III, IV*.	In or near BS, CB.	Nov.-March, as bags are filled.				
Transport from hunt camp to winter village.	Foot of draw Zone *III, IV* to terrace, Zone *I*.		Nov.-March, 1-3 days.	10-12 members of hunting group.	?Snowshoes, pack as above, including dried meat ?bones, ?temporary shelter, fuel.	Small amount fire-cracked rock (811), burnt soil (810), charred wood (701), ?unmodified cobbles (301).	Hearth, travel camp.
Store (platform) [1].	Terrace, Zone *I*.		Nov.-March.		Tule mats [1].	Post molds (804).	Storage area, winter village.

Table 1-7, cont'd.

DEER HUNTING: EXTENDED TRIP (cont.)	LOCATION		TIME	ENERGY SOURCES	CONJOINED ELEMENTS	OUTPUTS	ACTIVITY AREA
	ZONE	HABITAT					
Store (pit) [3].	Terrace, Zone *I*.		Nov.-March.		Split, flat rocks, sweet grasses [3].	Large soil depression (802), split, flat rocks (806).	Storage area, winter village.
Store (log house) [1].	Island, Zone *I*.	IS.	Nov.-March.		Tule mats [1].		
Store (talus cache or "rock shelter") [3].	Talus slope, Zone *I*.	RK.	Nov.-March.		Tule mats ?	Talus depression.	Storage area near winter village.
Prepare and eat dried meat. ±Roast meat [1, 3].	Terrace, Zone *I*.		Nov.-March.	Women of family [1], fire.	Fuel, long thin sticks.	Fire-cracked rock (811), burnt soil (810), charred wood, not pine or juniper (702).	Hearth, winter village.
±Boil meat [1, 3].	Terrace, Zone *I*.		Nov.-March.	Women of family [1], fire.	Fuel, cooking basket, water, ±berries, ±roots [1, 3].	Fire-cracked rock (811), burnt soil (810), charred wood (701), ±unmodified cobbles (301), ±berry seeds (704), ±root fragments (703).	Hearth, winter village.
±Make pemmican [1, 3].	Terrace, Zone *I*		Nov.-March.	Women of family.	Grinding implements (mortar and pestle or 2 rocks [1]), deer tallow [1, 3], berries [1].	Broken/abandoned grinding (112) implements.	±Dwelling, winter village.
Eat dried meat.	Terrace, Zone *I*.		Nov.-March.	Members of family.	Serving mats, ±cooking basket, ±wooden or horn spoon, ±sharp serving stick.	Broken/abandoned horn spoon (523).	Winter village.

REFERENCES:

[1] Ray 1932.
[2] Ray 1945.
[3] Spier 1938.
[4] Turner et al. 1977.
[5] Turner 1978.
[7[Turner 1979.

HABITAT TYPES:

IS = Island
RP = Riparian
SS = Shrub Steppe
MV = Macrophyllous Vine and Shrub
RL = Rockland
RK = Rock
BS = Broadleaf Tree Over Shrub
CB = Coniferous and Broadleaf Tree Over Shrub
CS = Coniferous Tree Over Shrub
CF = Coniferous Forest

KEY: ± = "sometimes"
() = Output number (see Appendix I for complete list of outputs).

Table 1-8. Activity chain model for Sanpoil-Nespelem deer hunting day trip (see bottom of table for key).

DEER HUNTING DAY TRIP	LOCATION		TIME	ENERGY SOURCES	CONJOINED ELEMENTS	OUTPUTS	ACTIVITY AREA
	ZONE	*HABITAT*					
± *Group hunting.* Plan hunt	Terrace, Zone *I*.		Nov.-Mar., evening before hunt	Leader and other men of hunt group [1].			
(Alt. 1) ± Drive deer [1].	From hills [1], down draws, to river [1], Zone *I*.		Nov.-Mar., 1 day.	Part of men of hunt group, dogs [1].	Crusted snow [1], ± snowshoes.		
Paddle up and down river [1].	Zone *I*.		Nov.-Mar., 1 day.	Remainder of men of hunt group [1].	Canoes [1], paddles.		
Stun deer in water [1] (± hold head under water until deer drowns! [1]).	Zone *I*.		Nov.-Mar., 1 day.	Remainder of men of hunt group [1].	Pounding implement (buckskin-covered wooden club[2]).		
Haul deer into canoe [1].	Zone *I*.		Nov.-Mar., 1 day.	Remainder of men of hunt group [1].	Canoes, paddles.		
(Alt. 2) ± Drive deer.	From hills over cliff [1], Zones *I, II*.		Nov.-Mar., 1 day.	All men of hunt group, dogs [1].	± Crusted snow, ± snowshoes.		
± *Individual hunting.* (Alt. 1) ± Stalk deer.			Nov.-Mar., 1 or more days.	Man or men of family [1].	±Snowshoes.		
Kill deer.			Nov-Mar., When deer becomes exhausted [1].	Man or men of family [1].	Cutting implement (hafted knife [1]).	Broken/abandoned cutting implements (102).	Dispersed.
(Alt. 2) ± Drive deer.	From hills down draw to valley [1], Zone *I*.		Nov.-Mar.	Boy of family, dogs [1].	Crusted snow [1], ±snowshoes.		
Shoot deer [1].	Foot of draw, Zone *I*		Nov.-Mar.	Men or men of family [1].	Bow and arrow [1], ±snowshoes.	Broken (202) or lost (201) projectile points	Dispersed, foot of draw, Zone *I*.
(Alt. 3) ± Hide at watering place [1].			Nov.-Mar. [1].	Man or men of family [1].	Trees [1].		
Shoot deer.			Nov.-Mar. [1].	Man or men of family [1].	Bow and arrow [1].	Broken (202) or lost (201) projectile points	Dispersed, watering place.
(Alt. 4) ± Dig hole in bank [1].			Nov.-Mar. [1].	Man or men of family [1].	Digging implements.	Large soil depression (302).	Salt lick.

Table 1-8, cont'd.

DEER HUNTING	LOCATION		TIME	ENERGY SOURCES	CONJOINED ELEMENTS	OUTPUTS	ACTIVITY AREA
DAY TRIP (continued)	*ZONE*	*HABITAT*					
± Build blind [1].			Nov.-Mar. [1].	Man or men of family [1].	± Poles, brush [1], ± rocks?	Rock alignment (805).	Salt lick.
Shoot deer [1].			Nov.-Mar. [1].	Man or men of family [1].	Bows, arrows.	Broken (202) or lost (201) projectile points.	Dispersed, salt lick.
(Alt. 5) ± Build spring snare [1].			Nov.-Mar. [1] rarely	Man or men of family [1].	Strong, flexible pole [1], noose of willow bark rope [1], brush, bait.		
Skin and butcher deer. ± Skin and cut up deer, extract brains for use in skin dressing [1].	Kill site, ± *Zone I*, ± *Zone II*.	In or near BS, CB.	Nov.-Mar., as needed.	One or more men, ± boys.	Cutting implements (stone knives, round or long blade [3]), chopping implements.	Broken projectile points (202), broken/abandoned cutting (101), chopping (104) implements, small amount bone (601), ± cranial bone (605), debitage (199).	Butchering area near kill site, (± foot of cliff, ± foot of draw, ± watering place, ± salt lick).
Transport ± meat, skin, bones, ± unbutchered deer from kill site to winter village.			Nov.-Mar., as needed.	One or more men, ± boys.	± Canoe, ± tumpline, ± snowshoes.		
± Skin and cut up deer, extract brains for use in skin dressing [1].	Terrace, *Zone I*.		Nov.-Mar., as needed.	Men of family.	Cutting implements (stone knives, round or long blade [3]), chopping implements.	Broken projectile points (202), broken/abandoned cutting (101), chopping (104) implements, small amount bone (601), ± cranial bone (605), debitage (199).	Butchering area, winter village.
Cook and eat fresh meat. Cut up meat.	Terrace, *Zone I*.		Nov.-Mar., as available.	Women of family [1].	Cutting implements (stone knives [3]).	Broken/abandoned cutting implements (101), lithic debitage (199).	Hearth area, winter village.
± Roast meat [1, 3].	Terrace, *Zone I*.		Nov.-Mar., as available.	Women of family [1], fire.	Fuel, long thin sticks.	Fire-cracked rock (811), burnt soil (810), charred wood, not pine or juniper (702).	Hearth area, winter village.
± Boil meat [1, 3] and/or blood [1].	Terrace, *Zone I*.		Nov.-Mar., as available.	Women of family [1], fire.	Fuel, ± cooking basket, water, ± berries, rocks, wooden tongs [1].	Fire-cracked rock (811), burnt soil (810), charred wood (701), ± unmodified cobbles (301), ± seeds (704).	Hearth area, winter village.
Eat fresh venison.	Terrace, *Zone I*.		Nov.-Mar., as available.	Members of family.	Serving mat, ± cooking basket, ± wooden or horn spoon, ± sharp serving stick [1].		
± Eat boiled blood, drink raw blood [1].	Terrace, *Zone I*.		Nov-Mar., as desired and available.	Men only [1].	±Basket.		

Table 1-8, cont'd.

DEER HUNTING DAY TRIP (continued)	LOCATION		TIME	ENERGY SOURCES	CONJOINED ELEMENTS	OUTPUTS	ACTIVITY AREA
	ZONE	HABITAT					
± Extract and eat marrow [1].	Terrace, *Zone I.*		Nov.-Mar., as desired and available.	Members of family.	Chopping, pounding implements.	Broken/abandoned chopping (104), pounding (115) implements, long bone splinters (604), lithic debitage (199).	Hearth area, winter village.
Dry meat. Build drying rack ± wind screen [1].	Terrace, *Zone I.*		Nov.-Mar., less than one day.		Cutting, chopping, pounding, wedging implements, willow poles [1], lashing material.	Broken/abandoned cutting (101), chopping (104), pounding (115), wedging (117) implements, lithic debitage (199), post molds (804).	Drying area, winter village.
Cut meat into thin strips, spread meat and bones on rack [1].	Terrace *Zone I.*		Nov-Mar., as available.	3-4 women of hunting group [1].	Cutting implements.	Broken/abandoned cutting (101) implements.	Drying area, winter village.
Dry meat and bones [1].	Terrace, *Zone I.*		Nov-Mar., as available, 24-48 hours each batch [1].	3-4 women of hunting group [1], fire	Willow [1] or other non-resinous fuel such as alder [5].	Large, rectangular area of burnt soil (810) and charred wood, not pine or juniper (702), ± fire-cracked rock (811).	Drying rack, drying area, winter village.
Strip bits of dry meat from bones [1].	Terrace, *Zone I.*		Nov-Mar., as meat dries.	3-4 women of hunting group [1].	Scraping implements.	Broken/abandoned scraping (106) implements, lithic debitage (199).	Drying area (?), winter village.
Deposit bones [1].	Terrace, *Zone I.*	BS, CB, CT, CF.	Nov.-Mar., as meat is eaten or dried.	7-8 men of hunting group.	Piece of old tule mat [1].	Bones (601).	Bone deposit area (in trees [1]), near winter village.
Store dried meat. See Table 7.							
Cook and eat dried meat. See Table 7.							

REFERENCES:

- [1] Ray 1932.
- [2] Ray 1945.
- [3] Spier 1938.
- [4] Turner et al. 1977.
- [5] Turner 1978.
- [7] Turner 1979.

HABITAT TYPES:

IS = Island
RP = Riparian
SS = Shrub Steppe
MV = Macrophyllous Vine and Shrub
RL = Rockland
RK = Rock
BS = Broadleaf Tree Over Shrub
CB = Coniferous and Broadleaf Tree Over Shrub
CS = Coniferous Tree Over Shrub
CF = Coniferous Forest

KEY: ± = "sometimes"
() = Output number (see Appendix 1 for complete list of outputs).

Table 1-9. Activity chain model for Sanpoil-Nespelem skin dressing (see bottom of table for key).

	LOCATION		TIME	ENERGY SOURCES	CONJOINED ELEMENTS	OUTPUTS	ACTIVITY AREA
SKIN DRESSING	*ZONE*	*HABITAT*					
Cut log [1] of aspen [7] 5-6" in diameter.	Draw with stream, Zone *I*.	BS, CB	May [7] ?	Men of family[3].	Chopping, wedging, pounding implements (maul and chisel [7]).	Broken/abandoned chopping (104), wedging (117), pounding (115) implements.	Dispersed, BS, CB.
Bevel upper end [7] and strip bark [1].	Draw or terrace, Zone *I*.		May [7] ?	Men of family[3].	Chopping implement.	Broken/abandoned chopping (104) implement.	Skin dressing area, winter village.
Soak skin [1].	Stream or lake, Zone *I*.		Nov.-Mar. ? 1-3 days [1].	Women of family [1].	Rocks to hold skin flat [1]		
Scrape off hair and flesh.	Terrace, Zone *I*.		Nov.-Mar.	Women of family [1].	Peeled aspen [7] log placed at angle against tree [1], scraping implement (curved bone [1]).	Broken/abandoned scraping (106) implement.	Skin dressing area, winter village.
Dry [1].	Terrace, Zone *I*.		Nov.-Mar., several hours.	Wind, sun			
Bury brains of one or two deer [1].	Terrace, Zone *I*.		Nov.-Mar., 2-3 days[1]	Women of family [1], fire.	Closed basket [1], digging implement.	Small depression (803) (7-8 inches deep [1]).	Near hearth, winter village.
Soak skin [1].	Terrace, Zone *I*.		Nov.-Mar., 12-48 hours	Women of family [1], fire.	Large basket [1]. Several gallons of warm water [1], partly decayed deer brains [1].		
Twist hide dry [1].	Terrace, Zone I.		Nov.-Mar.	1-2 women of family [1].	? Tree, one or two sticks [1].		
Stretch skin [1].	Terrace, Zone *I*.		Nov.-Mar.	Women of family [1].	Scraping frame [1], buckskin thong [1], piercing implement [1].	Broken/abandoned piercing (107) implement, post molds (804).	Skin dressing area, winter village.
Build two fires [1].	Terrace, Zone *I*.		Nov.-Mar.	Women of family [1].	Fuel.	Charred wood (701), burnt soil (810), ? fire-cracked rock (811).	Skin dressing area, winter village.
Scrape skin [1].	Terrace, Zone *I*.		Nov.-Mar. several hours [1].	Women of family [1], fire.	Fuel, scraping implement (hafted stone scraper of granite schist [1]).	Broken/abandoned scraping (105) implement.	Skin dressing area, winter village.
Dig small pit.	Terrace, Zone *I*.		Nov.-Mar.	Women of family [1].	Digging implement.	Small depression (803)(ca. 1 ft in diam., 1.5 ft deep [1]).	Skin dressing area, winter village.
Erect tripod over pit [1].	Terrace, Zone *I*.		Nov.-Mar.	Women of family [1].	Chopping, cutting implement, lashing material.	Broken/abandoned chopping (104), cutting (101) implement.	Skin dressing area, winter village.
Build fire in pit [1].	Terrace, Zone *I*.		Nov.-Mar.	Women of family [1].	Fuel (rotten pine or cedar [1]) (? juniper or willow [7]).	Charred wood (701).	Soil depression, skin dressing area, winter village.
Sew one or more skins together over tripod [1].	Terrace, Zone *I*.		Nov.-Mar.	Women of family [1].	Piercing implement, thread.	Broken/abandoned piercing implement (107).	Skin dressing area, winter village.
Smoke hides to water proof.	Terrace, Zone *I*.		Nov.-Mar. 4 hours or so.	Fire.			

Table 1-10. Activity chain model for Sanpoil-Nespelem root digging (see bottom of table for key).

ROOT DIGGING	LOCATION		TIME	ENERGY SOURCES	CONJOINED ELEMENTS	OUTPUTS	ACTIVITY AREA
	ZONE	*HABITAT*					
Prepare for root digging. Make/repair moccasins, mats, carry and gather baskets, storage bags, sleeping robes, digging sticks.	Terrace, Zone *I*.		Late March.	Women of village.	Cutting, piercing, abrading, pressure flaking implements, thread, basketry materials, patches, sticks of ironwood or mockorange [1].	Broken/abandoned cutting (101, 102), piercing (107), abrading (116), pressure flaking (120) implements, lithic debitage (199).	Spring village.
Pack digging sticks, fire drills, baskets, mats, bags, sleeping robes, tools, ? dried meat or fish [1].	Terrace, Zone *I*.		Early April.	Women of village.	Tumpline [1].		
Travel from spring village to root digging areas [1].	Terrace, Zone *I* to Zone *IIL* (and *IIIL?*) [1].		Early April.	Women of village in groups of 4-5 families each [1], ?men.	Pack as above, canoe.		
Erect temporary mat huts [1].	Zone *IIL*, (*IIIL?*).	Near RK, RL, BS, CB.	April-May, 30-40 days as often as necessary.	4-10 women of root digging group.	Poles, mats [1], cutting, chopping, wedging, pounding implements, lashing material.	Broken/abandoned cutting (103), chopping (104), wedging (117) pounding (115) implements, lithic debitage (199).	Root camp.
Dig roots. Plan next day's digging location [1].	Zone *IIL* (*IIIL?*).	Near RK, RL, BS, CB.	April-May, each evening [1] for 30-40 days.	Leader, other women of root digging group [1].			
Travel from root camp to preferred root field.	Zone *IIL* (*IIIL?*).		April-May, daily at dawn for 30-40 days [1].	Individual women of root digging group [1].	Digging sticks [1, 3], small gathering basket [3], large carrying basket [3], cutting implements.		
Dig preferred roots (e.g., *Lomatium canbyi*, *Lewisia rediviva*, other *Lomatiums*) [1].	Zone *IIL* (*IIIL?*).	RK, RL.	April-May, as supplies last.	4-10 women of root digging group.	Digging sticks [1, 3], small gathering baskets [3], large carrying baskets [3], cutting implements.	Broken/abandoned cutting (101) implements, lithic debitage (199).	Dispersed, preferred fields.
?Dig secondary roots (lower yield, lower quality, e.g., *Brodiaea douglasii* ?).	Zone *IIL* (*IIIL?*).	RK, RL, SS, CS, CF, BS, CB, MV, swamps.	April-May, as convenient.	4-10 women of root digging group.	Digging sticks, small gathering baskets, large carrying baskets, cutting implements.	Broken/abandoned cutting (101) implements, lithic debitage (199).	Dispersed, secondary areas.
Transport roots from root field to root camp.	Zone *IIL* (*IIIL?*)		April-May, each afternoon.	Individual women of root digging group.	Digging sticks, small gathering basket, large carrying basket of roots, cutting implement.		
Prepare roots for eating or drying. ?Roll on mat to loosen dirt (e.g., *Allium* spp.) [3].	Zone *IIL* (*IIIL?*)	Near RK, RL, BS, CB.	April-May, ?daily for 30-40 days.	Women of family [1].	Tule mat [3].		
?Beat to loosen skin (e.g., *Balsamorhiza sagittata*) [5].	Zone *IIL* (*IIIL?*).	Near RK, RL, BS, CB.	April-May, ?daily for 30-40 days.	Women of family [1].	Pounding implement.	Broken/abandoned pounding (116) implement.	Drying area, root camp.

Table 1-10, cont'd.

ROOT DIGGING (cont.)	LOCATION		TIME	ENERGY SOURCES	CONJOINED ELEMENTS	OUTPUTS	ACTIVITY AREA
	ZONE	*HABITAT*					
‡Peel (e.g., *Lomatium dissectum* [5], *L. macrocarpum* [4], *S. sagittata* [5].	Zone *IIL* (*IIIL?*).	Near RK, RL, BS, CB.	April-May, ‡daily for 30-40 days.	Women of family [1].	Cutting, scraping implements (?), mat (?).	Broken/abandoned cutting (101), scraping (105), lithic debitage (199).	Drying area, root camp
‡Wash (e.g., *Claytonia lanceolata* [5]).	Zone *IIL* (*IIIL?*)	Near RK, RL, BS, CB.	April-May, ‡daily for 30-40 days.	Women of family [1].	Basket (?)		
Cook and eat fresh roots. ‡Boil [1] (e.g., *L. canbyi* [5], *L. rediviva* [3]).	Zone *IIL* (*IIIL?*).	Near RK, RL, BS, CB.	April-May, ‡daily for 30-40 days.	Women of family [1].	Fuel, cooking basket, rocks, wooden tongs, cutting implement, water, ‡other ingredients.	Fire-cracked rock (811), burnt soil (810), charred wood (701), ‡unmodified cobbles (301), charred roots (703), broken/abandoned cutting (101) implements, lithic debitage (199).	Hearth, root camp
‡Basket steam [1] (e.g., *L. canbyi* [1], *Sium suave* [5])	Zone *IIL* (*IIIL?*).	Near RK, RL, BS, CB.	April-May, ‡daily for 30-40 days.	Women of family [1].	Fuel, cooking basket, rocks, grid of sticks, rock or plank cover [1], wooden tongs, water	Fire-cracked rock (811), burnt soil (810), charred wood (701), ‡unmodified cobbles (301), charred roots (703).	Hearth, root camp
‡Pit steam [1] (e.g., *L. canbyi* [5], *L. rediviva* [3], *Allium* spp. [3]).	Zone *IIL* (*IIIL?*).	Near RK, RL, BS, CB.	April-May, ‡daily for	Women of family or women of group [1].	Pit, flat rocks, fuel, grass or mats, peeled sticks, water [3, 5]	Large soil depression (802), burnt soil (810), fire-cracked rock (811), charred wood (700), charred grass or mats (706), charred root bits (703), ‡unmodified cobbles (301).	Earth oven, root camp.
Eat fresh roots.	Zone *IIL* (*IIIL?*).	Near RK, RL, BS, CB.	April-May, daily for 30-40 days.	Members of family	Serving mats, ‡raw vegetables, ‡antelope meat? [1] or small game [1].		
Dry roots. ‡On mats (e.g., *L. canbyi* [1], *L. rediviva* [4], *L. macrocarpum* [3].	Zone *IIL* (*IIIL?*).	Near RK, RL, BS, CB.	April-May, as appropriate	Women of family [1], sun, wind	Mats.		
‡Threaded on string or stick (e.g., *L. macrocarpum* [4], *S. sagittata* [5].	Zone *IIL* (*IIIL?*)	Near RK, RL, BS, CB.	April-May, as appropriate	Women of family [1], sun, wind	Piercing implement [? bone needle [3]], ‡thread or sinew, ‡long thin sticks [5].	Broken/abandoned piercing (107) implement	Drying area, root camp
‡Pulverized after boiling or steaming, formed into cakes, dried on mats (e.g., *Allium* spp. [3], *Lomatium farinosum* [4]).	Zone *IIL* (*IIIL?*)	Near RK, RL, BS, CB.	April-May, as appropriate.	Women of family [1], sun, wind.	Grinding implements, mats	Broken/abandoned grinding (113) implement.	Drying area, root camp.
Store roots. Pack dried and undried roots.	Zone *IIL* (*IIIL?*).	Near RK, RL, BS, CB	April-May, as roots accumulate.	Women of family.	Tule bags, piercing implement (needle [1]), thread	Broken piercing (107) implement.	Drying area, root camp.
Transport from root camp to winter village site.	Zone *IIL* (*IIIL?*) to terrace, Zone *I*.		April-May, as roots accumulate? (No temporary storage [1]).	Members of family	Packs as above, bags of roots, canoes.		

Table 1-10, cont'd.

	LOCATION		TIME	ENERGY SOURCES	CONJOINED ELEMENTS	OUTPUTS	ACTIVITY AREA
ROOT DIGGING (cont.)	ZONE	HABITAT					
Store undried roots (e.g., *C. lanceolata* [5], *L. macrocarpum* [3]).	Terrace, Zone I.		May-August?		Pit, grasses [5].	Large soil depression (802).	Storage area, summer village?
Store dried roots (platform) [1]	Terrace, Zone I.		May-±March.		Tule mats [1].	Post molds (804).	Storage area, winter village.
Store dried roots (pit) [3].	Terrace, Zone I.		May-±March.		Split flat rocks, sweet gras [3].	Large soil depression (802), large flat rocks (806).	Storage area, winter village.
Store dried roots (log house) [1].	Island, Zone I.	IS.	May-±March.		Tule mats [1].		
Store dried roots (talus cache or "rock shelter") [3].	Talus slope, Zone I.	RK.	May-±March.			Large talus depression (801).	Storage area near winter village.
Prepare and eat dried roots. ±Boil [1] (e.g., *L. rediviva* [3], *Lomatium* spp. [3, 4]).	Terrace, Zone I.		May-±March.	Women of family, fire.	Fuel, cooking basket, rocks, wooden tongs, water, ±dried meat or fish, ±berries, ±black moss [1, 3]	Fire-cracked rock (811), burnt soil (810), charred wood (710), ±unmodified cobbles (310), charred root fragments (703), charred frui seeds (704), charred moss (707).	Hearth, winter village.
±Pit roast [1] (e.g., *L. canbyi* [4], *Lewisia rediviva* [4], *Smilacina racemosa* [1, 4]).	Terrace, Zone I.		May-±March.	Women of family, fire.	Large pit, flat rocks, ±mats, ±grasses, ±ferns, peeled sticks, fuel, ±black moss [3].	Large soil depression (802), fire-cracked rock (811), burn soil (810), charred wood (710), charred mats, grasses, ferns (706), charred moss (707).	Earth oven, winter village.
Eat dried roots.	Terrace, Zone I.		May-±March.	Members of family.	Serving mats, ±cooking basket, ±wooden or horn spoon, ±sharp serving stick.	Broken/abandoned horn spoon (523).	Near hearth, winter village.

REFERENCES:

[1] Ray 1932.
[2] Ray 1945.
[3] Spier 1938.
[4] Turner et al. 1977.
[5] Turner 1978.
[7] Turner 1979.

HABITAT TYPES:

IS = Island
RP = Riparian
SS = Shrub Steppe
MV = Macrophyllous Vine and Shrub
RL = Rockland
RK = Rock
BS = Broadleaf Tree Over Shrub
CB = Coniferous and Broadleaf Tree Over Shrub
CF = Coniferous Forest
CS = Coniferous Tree Over Shrub

KEY: ± = "sometimes"
() = Output numbers (see Appendix 1 for complete list of outputs).

Table 1-11. Activity chain model for Sanpoil-Nespelem fishing (see bottom of table for key).

FISHING	LOCATION		TIME	ENERGY SOURCES	CONJOINED ELEMENTS	OUTPUTS	ACTIVITY AREA
	ZONE	*HABITAT*					
Construct platform/ weir.							
Gather willow poles and withes [1, 3].	Draws, streambeds, Zone I, (III) [4].	BS, CB	Late Apr.- early May [1].	Men of village[1].	Chopping, cutting, wedging, pounding implements.	Broken/abandoned chopping(104) cutting (101), wedging (117), pounding (115) implements, lithic debitage (199).	Dispersed, BS, CB, near summer village.
Gather pine saplings [1, 3].	Zone IIIB.	CS, CB	Late Apr.- early May [1].	Men of village[1].	Chopping, cutting, wedging, pounding implements.	Broken/abandoned chopping(104) cutting (101), wedging (117), pounding (115) implements, lithic debitage (199).	Dispersed, CF, CS, CB, near summer village.
Gather serviceberry withes [1].	Draws, streambeds, talus slopes, Zone I.	RK, CF, CS, MV, BS, CB	Late Apr.- early May [1]	Men of village[1].	Chopping, cutting implements.	Broken/abandoned chopping(104) cutting (101) implements, lithic debitage (199).	Dispersed, MV, BS, CB, CS, CF, RK, near summer village.
Gather brush [1].	Terraces, draws, streambeds, Zone I.	SS, MV, BS	Late Apr.- early May [1].	Men of village[1].			
Dig channel(s) [1].	River bed at rapids [1].		Late Apr.- early May [1].	Men of village[1].	Digging implements, white quartz cobbles [1].	Concentrations of white quartz cobbles (301).	River bottom or edge at rapids.
Construct tripods [1, 3].	Low terrace near rapids, Zone I.		Late Apr.- early May [1].	Men of village[1].	Pine poles [1, 3], chopping, cutting, scraping implements, withes.	Broken/abandoned chopping(104) cutting (101), scraping (106) implements, lithic debitage (199).	Woodworking area [3], riverbank at fishing location, summer village.
Erect platform [1].	In river at rapids, Zone I.		Late Apr.- early May [1].	Men of village[1].	Pounding, chopping, scraping digging implements, boulders for bracing tripod legs, willow and serviceberry withes [1].	Broken/abandoned pounding(115) chopping (104), scraping (106) implements, lithic debitage (199).	Fishing location river bottom or edge.
Construct weir [1].	In river at rapids, Zone I.		Late Apr.- early May [1]	Men of village[1].	Pounding, chopping implements, withes, brush [1].	Broken/abandoned pounding(115) chopping (104) implements, lithic debitage (199).	Fishing location river bottom or edge.
Fish.							
Spear steelhead and chinook [1].	At rapids, Zone I.		Early May - July [1].	Men of family[1].	Fish spear [1], stringer poles.	Broken/abandoned bone spear points (203), horn sockets (204)	Fishing location river bottom or edge.
Net salmon, smaller fish [1].	At rapids, where water turbid [1], Zone I.		Early May - July [1].	Men and women of family [1].	Dip nets, stringer poles [1].		
Cook and eat fresh fish. ? Boil [1].	Low terrace near rapids, Zone I.		Early May - July, once or twice daily [1].	Women of family [1], fire.	Fuel, basket [1], cooking rocks [1], cutting implements, wooden tongs [1], water, ? roots, ? berries, ? seeds [1].	Fire-cracked rock (811), burnt soil (810), charred wood(701), ? unmodified cobbles (301), fish bone (606), ? root (703) berry (704), seed(705)remains	Hearth, summer village.

Table 1-11, cont'd.

	LOCATION		TIME	ENERGY SOURCES	CONJOINED ELEMENTS	OUTPUTS	ACTIVITY AREA
FISHING	*ZONE*	*HABITAT*					
± Roast [1].	Low terrace near rapids Zone *I*.		Early May - July, once or twice daily [1].	Women of family [1], fire.	Fuel, long thin stick [1].	Fire-cracked rock (811), charred wood (702), burnt soil (810).	Hearth, summer village.
Eat fish.	Low terrace near rapids Zone *I*.		Early May - July [1], once or twice daily [1].	All family members [1].	Serving mats [1], ± basket [1], ± spoons [1], ± sharp serving stick [1], ± fresh berries [1].		
Deposit bones [1].	Low terrace near rapids Zone *I*.		Early May - July [1].	Men of family [1]	Piece of tule mat.	Fish bones (606).	Bone depository (trees [1]) near summer village.
Dry fish. Clean fish (gut) [1].	Low terrace near rapids Zone *I*.		Early May - July [1], daily ?	Women of family.	Cutting implements (stone or bone salmon knife [2]), mats ?	Broken/abandoned cutting implements (101), lithic debitage (199).	Fish drying area, summer village
Dry fish (preliminary) [1].	Low terrace near rapids Zone *I*.		Early May - July, ca. one hour daily [1].	Women of family sun, wind.			
Slash and pierce fish.	Low terrace near rapids Zone *I*.		Early May - July [1], daily ?	Women of family.	Cutting, piercing implements, wooden splints [1].	Broken/abandoned cutting (101), piercing (107) implements.	Fish drying area,
Dry fish (final) [1].	Low terrace near rapids Zone *I*.		Early May - July [1].	Women of family [1], sun, wind.	Forked sticks (for hanging bodies by tails) [1].	Occasional fish bone (606).	Under drying rack fish drying area, summer village.
Store dried fish. Pack.	Low terrace near rapids Zone *I*.		May - July [1], daily as fish dry ?	Women of family [1].	Tule bags, ± dragon sagewort (*Artemisia dracunculus*), piercing implement, thread.	Broken/abandoned piercing implement (107).	Fish drying area, summer village.
Store (temporary), roof of dwelling [1]).	Low terrace near rapids Zone *I*.		Early Sept. - mid Oct. [1].				
Transport from summer village to winter village.	Zone *I*.		Mid Oct. [1].		Tumplines ? Canoes ?		
Store (platform) [1].	Terrace, Zone *I*.		Nov.-March		Tule mats [1].	Post molds (804).	Storage area, winter village.
Store (pit) [3].	Terrace, Zone *I*.		Nov.-March		Split, flat rocks, sweet grasses [3].	Large soil depression (802), split, flat rocks (806).	Storage area, winter village.
Store (log house) [1]	Island, Zone *I*.	IS.	Nov.-March		Tule mats [1].		

Table 1-11, cont'd.

FISHING	LOCATION		TIME	ENERGY SOURCES	CONJOINED ELEMENTS	OUTPUTS	ACTIVITY AREA
	ZONE	*HABITAT*					
Store (talus cache or "rock shelter") [3].	Talus slope Zone *I*.	RK	November - March.		Tule mats ?	Talus depression (801).	Storage area near winter village.
Prepare and eat dried fish. ± Boil [1].	Terrace, Zone *I*.		Mid Oct. - spring [1].	Women of family [1], fire	Fuel, cooking basket, rocks, cutting implements, wooden tongs, water, ± roots, ± berries [1], ± seeds ?	Fish bones (606), root (703), seed (705), berry (704) remains, fire-cracked rock (811), burnt soil (810), charred wood remains (701), ± unmodified cobbles (301)	Hearth, winter village.
Make pemican [1].	Terrace, Zone *I*.		Mid Oct. - spring [1].	Women of family.	Griding implements (mortar and pestle or two rocks [1]), berries, sunflower meal, fat [1].	Broken/abandoned grinding implements (112).	± Dwelling, winter village.
Eat fish.	Terrace, Zone *I*.		Mid Oct. - spring, ± daily.	All family members.	Serving mats, ± basket, ± wooden or horn spoon, ± sharp serving stick [1].	Fish bones (606), broken/ abandoned horn spoon (523).	Near hearth, winter village
Deposit bones [1].	Terrace, Zone *I*.		Mid Oct. - spring, ± daily.	Men of family.	Piece of tule mat. ,	Fish bones (606).	Bone depository (trees [1]) near winter village.

REFERENCES:

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Table 1-12. Activity chain model for Sanpoil-Nespelem flaked stone tool manufacture (see bottom of table for key).

FLAKED STONE TOOL MANUFACTURE	LOCATION		TIME	ENERGY SOURCES	CONJOINED ELEMENTS	OUTPUTS	ACTIVITY AREA
	ZONE	*HABITAT*					
Obtain raw material. Travel from summer or winter village to ±beach outcrop, ±quarry, or ±trade area.	Terrace, Zone *I* ±to beach outcrop, Zone *I*, ±Zone *IIL*, *IIIL*, ±rapids, Zone *I*.		Spring-fall.	One or more men or women.	Tumpline, fire drills, mats, baskets, sleeping robes, dried food, ±quarrying tools (picks, scrapers, hammers, wooden and bone billets, wedges), ±pressure flaking tools, ±abrader, ±leather pads [1, 2, 6].	Small amount fire-cracked rock (811), burnt soil (810), charred wood (701).	Hearth, travel camp.
Erect temporary mat huts.	±Near beach outcrop, Zone *I*, ±near raw material source, Zone *IIL*, *IIIL*, ±near rapids, Zone *I*.	BS, CB	Spring-fall.	One or more men or women.	Poles, mats, cutting, chopping, wedging, pounding implements, lashing material.	Broken/abandoned cutting (101), chopping (104), wedging (117), pounding (115) implements.	±Beach camp, ±quarry camp (may be same as hunt camp or root camp), ±trade camp (may be same as fish camp).
Travel ±from beach camp to outcrop, ±from quarry camp to quarry.	±Zone *I*, ±Zone *IIL*, *IIIL*.		Spring-fall.	One or more men or women.	±Quarrying and flaking implements.		
±Select cobbles/nodules from beach outcrop [1].	Zone *I*, *IIR*		Spring-fall (±winter).	One or more men or women.			
Decortify cobbles/nodules selected from beach outcrop [4, 9].	Zone *I*, *IIR*		Spring-fall (±winter).	One or more men or women.	Percussion flaking implements, ±anvil [1, 6].	Broken/abandoned percussion flaking implements (119), broken/abandoned anvil (121), primary (402) and secondary (403) decortication flakes, tertiary flakes (404), ±bipolar flakes (405), broken cores (406), usable (303) and flawed (304) chunks, lithic debitage (199) [1, 2, 4, 6, 9].	±Beach outcrop, ±manufacturing area, beach camp, ±manufacturing area, summer or winter village.
±Extract raw material from quarry [1, 2].	Zone *IIL*, *IIIL*.		Spring-fall.	±3 or more men [1].	Chopping, scraping, pounding, wedging implements (picks, scrapers, hammers, wedges [1, 2]), detritus usable for quarrying.	Broken/abandoned chopping (104), scraping (106), pounding (115), wedging (118) implements, usable (303) and flawed (304) chunks, percussion flakes (408) (hardhammer) of both flawed and high quality material, lithic debitage (199) [1, 2, 6, 8, 9].	Quarry.
±Pare to remove flawed material [1, 2].	Zone *IIL*, *IIIL*.		Spring-fall.	One or more men.	Percussion flaking implements (wooden and bone billets, hammers) [1], ±anvil [1, 6].	Broken/abandoned percussion flaking implements (119), usable (303) and flawed (304) chunks, percussion flakes (408) (hardhammer and softhammer), ±bipolar flakes (405), lithic debitage (199) [1, 2, 6].	Quarry.
±Obtain raw material through trade.	Near rapids, Zone *I*. (±outside study area).		Spring-fall.				

Table 1-12, cont'd.

FLAKED STONE TOOL MANUFACTURE (cont.)	LOCATION		TIME	ENERGY SOURCES	CONJOINED ELEMENTS	OUTPUTS	ACTIVITY AREA
	ZONE	*HABITAT*					
Manufacture flaked stone tools. Reduce to core or blank.	±Zone *I*, ±Zone *II*L, *III*L.	BS, CB		One or more men or women.	Percussion flaking implements, ±anvil [1, 6].	Broken/abandoned percussion flaking implements (119), broken (406) or exhausted (411) cores, blanks (412), broken formed objects (413) [2], usable (303) and flawed (304) chunks, prepared cores (401), broken/abandoned anvil (121), secondary decortication (403) and tertiary (405) flakes, ±bipolar flakes, broken/abandoned abrading implement (116), lithic debitage (199) [1, 2, 3, 7].	±Beach outcrop, ±manufacturing area, beach camp, ±quarry, ±manufacturing area, quarry camp (or root, hunt camp), ±trade camp, ±manufacturing area, winter or summer village. (Near source [2, 7]).
±Transport from source to beach camp or quarry camp.	±Zone *I*,*II*R ±Zone *II*L, *III*L.		Spring-fall.	One or more men or women.	Baskets?		
Further reduce objects.	±Zone *I*,*II*R ±Zone *II*L, *III*L.		Spring-fall.	One or more men or women.	Percussion flaking implements, ±anvil, pressure flaking implements (pointed bone, wood, copper objects [6]), leather pad.	Broken/abandoned percussion (119) and pressure (120) flaking, abrading (116) implements, anvil (121), usable (303) and flawed (304) chunks, cores (401), broken (406) and exhausted (411) cores, bipolar (405), tertiary (404), and pressure (409) flakes, tool blanks (412), whole (407) and broken (413) formed objects, lithic debitage (199).	±Beach outcrop, ±manufacturing area, beach camp, ±quarry, ±manufacturing area, quarry camp (or root, hunt camp), ±manufacturing area, winter or summer village.
Repair tools [6].	±Zone *I*,*II*R ±Zone *II*L, *III*L.	BS, CB	Year round.		Percussion flaking and pressure flaking implements, abrading stone [6], leather pad [6].	Broken/abandoned abrading (116), percussion flaking (119), pressure flaking (120) implements, broken/abandoned anvil (121), whole (407) and broken (413) formed objects, pressure flakes (409), lithic debitage (199).	±Beach outcrop, ±manufacturing area, beach camp, ±quarry, ±manufacturing area, quarry camp (or root, hunt camp), ±manufacturing area, winter or summer village.
±Cache quarrying tools.	±Zone *I*, ±Zone *II*L, *III*L.	BS, CB			Chopping, pounding, wedging, scraping implements (picks, hammers, wedges, billets, scrapers [1, 2].)	Whole chopping (104), pounding (115), wedging (118), scraping (106) implements.	±Quarry, ±quarry camp, ±summer or winter village.
±Transport raw materials, partly formed and formed objects, ±quarrying tools ±from beach camp ±from quarry camp, ±from trade camp to summer or winter village.					Packs as above.	Small amount fire-cracked rock (811), burnt soil (810), charred wood (701).	Hearth, travel camp.
±Cache (source) raw materials, tools.	±Zone *I*,*II*R ±Zone *II*L, *III*L.	BS, CB				Scraping (106), wedging (118), percussion flaking (119) implements, anvil (121), cobbles (301), modules (303), chunks (30[illegible]).	±Beach camp, ±quarry camp.

Table 1-12, cont'd.

FLAKED STONE TOOL MANUFACTURE (cont.)	LOCATION		TIME	ENERGY SOURCES	CONJOINED ELEMENTS	OUTPUTS	ACTIVITY AREA
	ZONE	HABITAT					
±Cache (±at beach camp, ±at quarry camp) raw materials, manufacturing tools.	±Zone I,IIR ±Zone IIL, IIIL.	SS, BS, CB, CS.				Whole abrading (116), percussion (119) and pressure (120) flaking implements, anvils (121), unmodified cobbles (301), nodules (302), and usable chunks (303).	±Manufacturing area, beach camp, ±manufacturing area, quarry (or root, hunt) camp.
±Cache (±at summer village, ±at winter village) raw materials, partly formed and formed objects, manufacturing tools.	Zone I.	SS, BS, CB				Worn objects, formed and unformed (100), unmodified cobbles (301), nodules (302), usable chunks (303), prepared cores (401), percussion flakes (408), tool blanks (412), whole formed objects (407).	±Manufacturing area, summer village, ±manufacturing area, winter village.
±Thermally alter [1,5] cores (?), blanks [6], raw materials (?).	±Zone I,IIR ±Zone IIL, IIIL.	SS, BS, CB, CS		One or more men or women, fire.	Fuel, water.	Fire-cracked rock (811), burnt soil (810), charred wood (701), heat spalled (414) and crazed (415) cores (401) (406), blanks (412), whole (407) and broken (413) formed objects, percussion flakes (408), and chunks (304) [1,5].	±Hearth, beach camp, ±hearth quarry (or root, hunt) camp, ±hearth summer village, ±hearth winter village.
±Reduce to final desired shape.	±Zone I, ±Zone IIL, IIIL.		Any time.	Men and women?	Percussion and pressure flaking implements, leather pad	Broken/abandoned percussion (119) and pressure (120) flaking implements, abrading implement (116), exhausted cores (411), tertiary (404) flakes (hardhammer, softhammer), pressure flakes (409) broken formed objects (413), lithic debitage (199)[1, 6, 8, 9].	±Manufacturing area, beach camp, ±manufacturing area, quarry (or root, hunt) camp, ±manufacturing area, summer village, ±manufacturing area, winter village.

REFERENCES:

[1] Crabtree 1972.
[2] Bryan 1950.
[3] Holmes 1890
[4] Sharrock 1966.
[5] Crabtree and Butler 1964.
[6] Crabtree 1967b.
[7] Bryan and Tuohy 1960.
[8] Stafford 1979.
[9] Muto 1971.

HABITAT TYPES:

IS = Island
RP = Riparian
SS = Shrub Steppe
MV = Macrophyllous Vine and Shrub
RL = Rockland
RK = Rock
BS = Broadleaf Tree Over Shrub
CB = Coniferous and Broadleaf Tree Over Shrub
CS = Coniferous Tree Over Shrub
CF = Coniferous Forest

KEY: ± = "sometimes"
() = Output number (see Appendix 1 for complete list of outputs).

area, refers to a locus of activity defined by a cluster of material outputs. Activity areas may be usefully defined at a variety of scales. We have assigned a few outputs to very specific activity loci described by ethnographers (e.g., "hearth area" or "earth oven"), but most are assigned to more general activity areas such as "root drying area" or "butchering area." Given present information, a few others can only be assigned to more inclusive units such as "quarry camp" at this time. The term "dispersed," sometimes followed by a physiographic zone or habitat type designation, is used to describe output scatters of very low density.

For the sake of compactness, several symbols and abbreviations are used both in Tables 1-7 to 1-12 and in accompanying flow charts (Figures 1-15 and 1-16). Alternative or hypothetically infrequent actions, objects, locations, times, conjoined elements, and activity areas are marked by the symbol (*), which may be read "sometimes." This symbol is not generally used in the outputs component, however, since it is assumed from the beginning that the listed artifacts are *possible* outputs; they do not *necessarily* occur each time the action is perfomed. Habitat type abbreviations follow Erickson et al. (1977). Bracketed numbers (e.g., [1] signify references. Entries not followed by a reference are inferential (following Schiffer 1976). The most questionable references are followed by a question mark. Numbers in parentheses refer to the list of expected outputs (Appendix 1). Location is inferred either from a combination of ethnographic information and the environmental data discussed in previous sections or from environmental data alone.

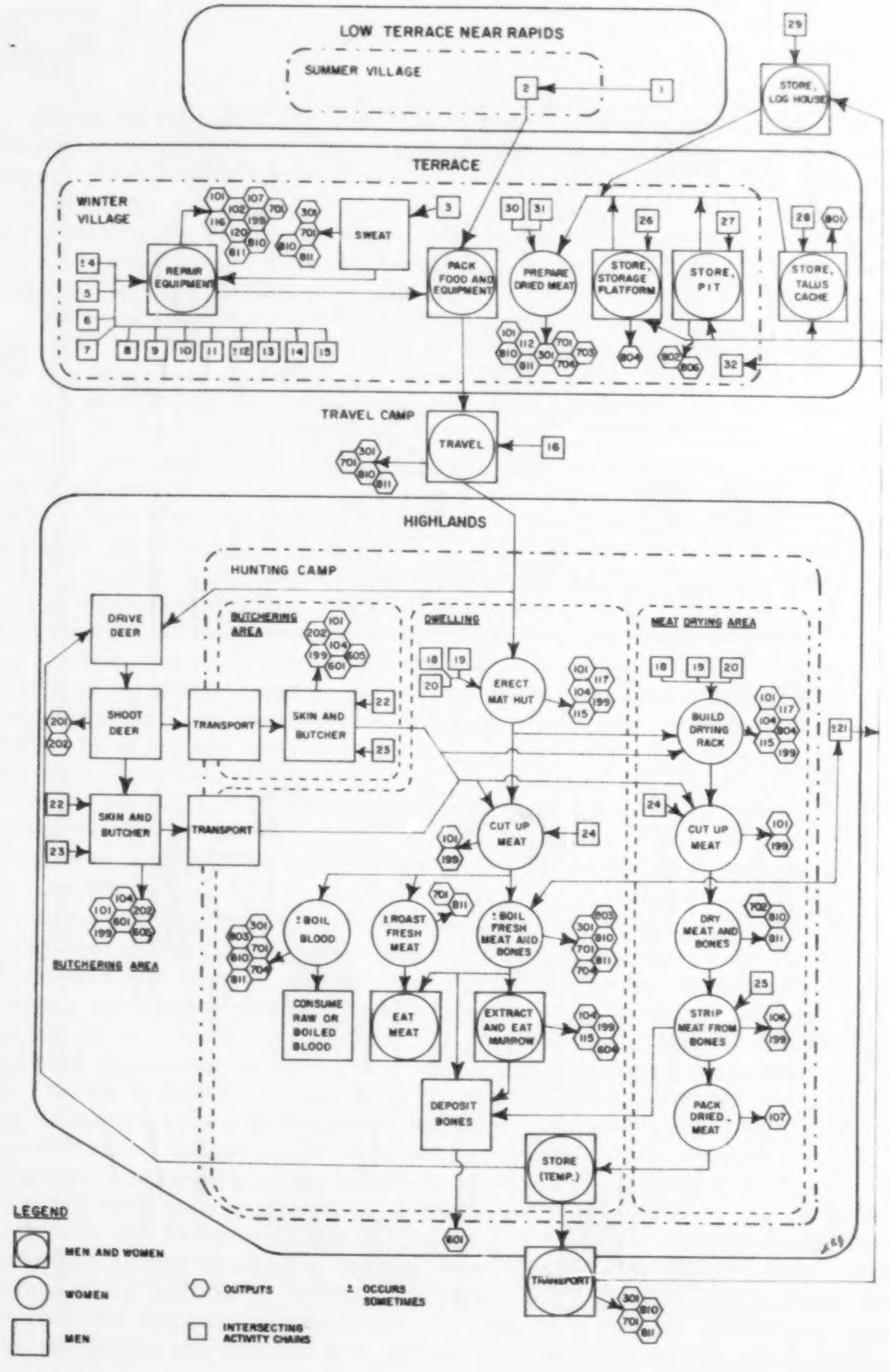
Each segment, then, constitutes a complex sentence. For instance, the seventh segment of Table 1-7, which begins with the activity "shoot deer," may be read as follows: "as the opportunity arises during an extended trip occurring between November and March, two or three men of the hunting group, at the head of a draw associated with habitat types "broadleaf tree over shrub" or "coniferous and broadleaf tree over shrub" in either Zone III or Zone IV, sometimes wearing snowshoes and with bows and arrows, shoot deer, occasionally resulting in the dispersed deposition of lost and broken projectile points." A series of such segments constitutes one loop in the continuing cycle of the hunter-gatherer subsistence-settlement system as hypothesized in the ethnographies and implies specific clusters of outputs in association with other clusters, which often are assigned to specific physiographic zones and habitat types.

The tabular form of activity chain analysis is merely a series of primitive equations or logical relations of the form, "in conditions C, (or given stipulations S), if hypothesis H, then test implication T." The components of the equations may be reformulated in a number of ways. For guiding artifact analysis, the archaeological implications (i.e., the outputs of artifacts and features) may be summarized by location. For synthetic analyses, the table of equations may be reformulated as a flowchart (e.g., Figure 1-15). The flowchart has the advantage of condensing an immense amount of information into a single graphic display, in emphasizing the spatial relationships among the activities, in specifying the location of interconnecting chains, and in laying the groundwork for simulation modeling.

Figure 1-15. Flow model of extended deer hunting trip.

Key to intersecting behavioral chains.
(See Appendix A for key to outputs)

1. Fishing
2. Drying and storage of fish
3. Construction of sweat lodge
4. Snowshoe manufacture
5. Bow manufacture
6. Arrow manufacture
7. Projectile point manufacture
8. Tule mat production
9. Storage bag production
10. Production of sleeping robes
11. Basket making
12. Manufacture of horn implements
13. Cordage manufacture
14. Bone tool manufacture
15. Flaked stone tool repair
16. Cooking - fish
17. Construction of mat huts
18. Manufacture of cutting implements for woodworking
19. Manufacture of chopping implements for woodworking
20. Construction of drying rack
21. Berry gathering and preservation
22. Manufacture of cutting implements for butchering
23. Manufacture of chopping implements for butchering
24. Manufacture of cutting implements for cooking
25. Manufacture of scraping implements
26. Construction of storage platform
27. Construction of storage pit
28. Construction of talus cache
29. Construction of log storage house
30. Root gathering and preservation
31. Manufacture of grinding implements for cooking
32. Skin dressing


LOW TERRACE NEAR RAPIDS
SUMMER VILLAGE
TERRACE
WINTER VILLAGE
REPAIR EQUIPMENT
SWEAT
PACK FOOD AND EQUIPMENT
PREPARE DRIED MEAT
STORE, STORAGE PLATFORM
STORE, PIT
STORE, TALUS CACHE
STORE, LOG HOUSE
TRAVEL CAMP
TRAVEL
HIGHLANDS
HUNTING CAMP
BUTCHERING AREA
DWELLING
MEAT DRYING AREA
DRIVE DEER
SHOOT DEER
TRANSPORT
SKIN AND BUTCHER
ERECT MAT HUT
BUILD DRYING RACK
CUT UP MEAT
± BOIL BLOOD
± ROAST FRESH MEAT
± BOIL FRESH MEAT AND BONES
DRY MEAT AND BONES
CONSUME RAW OR BOILED BLOOD
EAT MEAT
EXTRACT AND EAT MARROW
STRIP MEAT FROM BONES
DEPOSIT BONES
PACK DRIED MEAT
STORE (TEMP.)
BUTCHERING AREA
LEGEND
MEN AND WOMEN
WOMEN
MEN
OUTPUTS
INTERSECTING ACTIVITY CHAINS
± OCCURS SOMETIMES

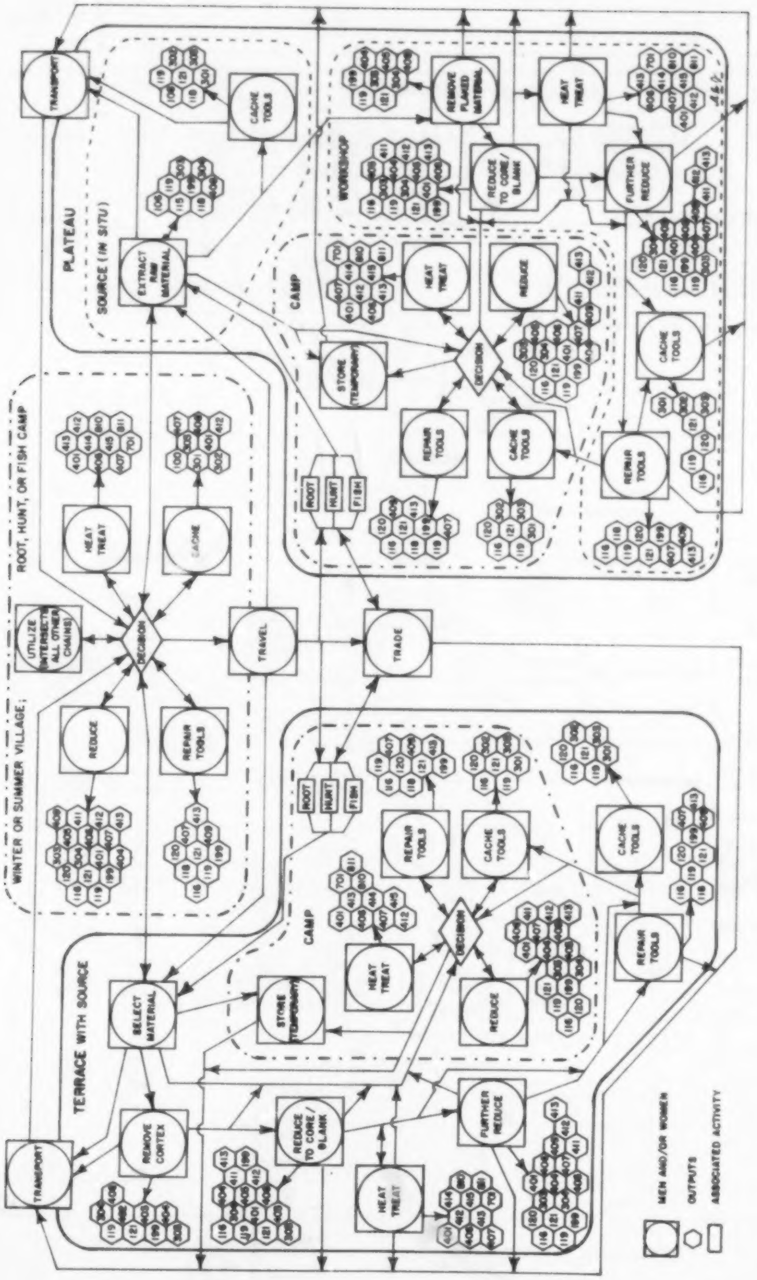

PLATEAU
SOURCE (IN SITU)
EXTRACT RAW MATERIAL
CACHE TOOLS
TRANSPORT
WORKSHOP
REMOVE FLAKED MATERIAL
HEAT TREAT
REDUCE TO CORE/BLANK
FURTHER REDUCE
CAMP
STORE (TEMPORARY)
DECISION
REDUCE
REPAIR TOOLS
ROOT
HUNT
FISH
WINTER OR SUMMER VILLAGE; ROOT, HUNT, OR FISH CAMP
UTILIZE (INTERSECTS ALL OTHER CHAINS)
CACHE
TRAVEL
TRADE
TERRACE WITH SOURCE
SELECT MATERIAL
REMOVE CORTEX
MEN AND/OR WOMEN
OUTPUTS
ASSOCIATED ACTIVITY

Figure 1-16. Flow model of flaked stone tool manufacture (see Appendix A for key to outputs).

Hunting

Three related deer hunting sequences are presented here, Deer Hunting: Extended Trip (Table 1-7), Deer Hunting: Day Trip (Table 1-8), and Skin Dressing (Table 1-9), a sequence which may follow either of the other two. While antelope, elk, bear, small game, and furbearing animals are mentioned in the literature as minor sources of meat, only deer hunting is described in detail. Although antelope were reportedly hunted in Zone IIIL from early summer through fall, deer provided most of the meat eaten during the winter.

There is an apparent contradiction in the literature about the time of major deer hunting: Ray specifies winter (between November and March) and Spier and associates specify fall (between September and December), commenting that the deep snows of winter made deer hunting difficult. The seasonal variation in deer density and community behavior presented earlier suggest that both fall and winter would have been appropriate times, although weights would have been higher in fall before winter stress and rutting. It is doubtful that the deer hunting practices of the Sanpoil-Nespelem and Sinkaietk peoples differed much. The apparent differences are more likely to be an artifact of the small sample of informants and of the rapid environmental-cultural changes during the nineteenth century. Exact time and zone of hunting normally would vary from year to year depending upon snow accumulation, rainfall and browse availability, population densities, and location of winter villages. Use of the horse and rifle during the nineteenth century is likely to have extended trip distances and altered the returns expected in different seasons. We follow the winter sequence in the examples given here, although alternatives for fall hunting are included, since women's activities during a fall hunt are said to have included berrying. For the prehistoric central-based system, as well as for a foraging system, the Zone I, II winter day trip of one variety or another (see Table 1-8) is the more likely pattern.

"Space" is used in two different ways in the flowchart. Actual geographical space is indicated with respect to zone and physiographic feature, but the spatial organization of particular activity areas is only indicated in a hierarchical schematic form. That is, under certain circumstances, a hunt camp in Zone III or IV will include (if the ethnography is correct) a butchering area, some temporary dwellings, and a meat drying area. While we presume these activity areas will be spatially related in such a way as to minimize distances and maximize efficiency, the exact form cannot be predicted. A number of alternative arrangements are expressed in the ethnographic documents. For instance, when there has been a particularly successful hunt high up a draw away from base camp, the deer are sometimes skinned and butchered near the kill site. At the hunt camp, the meat is cut into strips by the women and laid out for drying. The literature is vague, however, about just what parts of the animal were brought back to camp and what was left behind. Although one can imagine a primary butchering area in which the joints and saddles are dressed out and returned to the in-camp butchering area for further processing, this alternative has not been included here.

Another important element of the hunting subsystem modeled here is its contribution to modeling the complex habitation activity areas in Zone I (e.g., Figure 1-15). While all subsystems, under the ethnographic model, articulate with the winter village, hunting and associated activities account for a large number of potentially recoverable outputs. Even though activities related to vegetable products may outweigh those related to hunting, fewer recoverable outputs are expected, especially at the winter village. That does not mean, however, that we should ignore sequences related to utilization of vegetable resources. On the contrary, the amount of vegetable resources in the resource base has important and predictable consequences in activity area location.

Plant Utilization

A bias toward masculine pursuits and status foods found by Lee (1969; see also various articles by Lee and DeVore 1968) also is evident in the ethnographic records used here. While it is clear from the records of building styles and materials and from the conjoined elements components of most activity sequences that the collection and preparation of rushes, grasses and fibrous plants alone must account for a great deal of time and effort, perhaps as much as fishing and hunting combined, only the collection of food resources is described in detail in the primary ethnographies. References to important technological resources such as tules and Indian hemp are scattered and fragmentary. We are told what they were used for and, in some cases, how they were used, but not when, where, and how they were gathered. Information about the use of various woods is sparser still. With the aid of environmental studies and recent ethnobotanies, however, we have compiled a digest of plant resources mentioned by Ray and Spier, with their locations, the season they are available, the methods by which they were procured, the methods by which they were preserved, stored, and cooked (if applicable), and their technological uses. From this we have constructed a month by month description of the plant resource base for Zone I. These in turn were used as the basis for all activity chains related to plant utilization. The plant utilization activity chains are thus more hypothetical than the hunting and fishing examples. The complete digest is too bulky for inclusion here; only the activity sequence for spring root gathering, the plant procurement activity described in most detail in the ethnographies, is presented here (Table 1-10).

One of the curiosities of Ray's ethnography is that root gathering is relegated to a single season (May-June) and primarily to a single locality (south of the Columbia River). While Ray mentions trips to the Grand Coulee, our preliminary reconnaissance suggests that Zone IIL is the primary locality of high-yield spring root crops, and may have been the primary zone exploited before the coming of the horse and homesteading of the Plateau. Nevertheless, both ethnographic and our field research suggest some utilization of roots throughout the year in most zones of the study area.

Fishing

The tabular chain analysis presented here (Table 1-11) deals with the activities involved with fishing from platforms at rapids. This should account for most of the fishing activity in the sample area. There are only two permanent streams in the sample area of sufficient size and permanence for spawning, and both are blocked by falls at the Zone I/IIR boundary. Of the two, only the Nespelem has short stretches of shallows suitable for spawning. The ethnographies indicate that a fish trap was located at the mouth of the Nespelem River in historic times. Nonetheless, the productivity is unlikely to have been high because the stretch of river suitable for spawning is so short.

Three other fishing sequences could also be constructed: fishing with traps, fishing with lines from canoe or shore, fishing with poisons in upland streams. Most of the outputs for these activities, like those for fishing from platforms at rapids, will be deposited in the river or will represent dispersed clusters in tree and brush habitats.

The most important aspect of fishing is its demand on time and energy and on wood resources. From the sheer computation of numbers, weight, nutritional value, and density, one may infer that fishing along the Columbia represented the prime factor in resource use scheduling and settlement location. The analysis here suggests that the controlling factor in activity area location, however, may not be rapids, *per se*, but rapids at a minimum distance from plentiful supplies of raw materials such as willow, pine saplings, and other coniferous trees, broadleaf trees, and shrubs.

While the importance of fishing and connected activities should exert a strong influence on settlement location, outputs will clearly provide little in the way of activity area definition. Outputs from the collecting of construction materials are dispersed along draws, at the bases of talus slopes, and along the river beaches in riparian habitats. Outputs from fishing itself will be located in the river or on the beach. Outputs from preparation and drying will occur mainly in the summer village, while those from consumption may occur anywhere. Distinctive outputs from comsumption are expected to survive largely as microscopically identifiable constituents in soil samples from site features (Casteel 1974a, 1974b, 1976; Limp and Reidhead 1979; Garson 1980).

Stone Tool Manufacture

Because of the paucity of ethnographic information about the manufacture of flaked stone tools in the Plateau region, the activity chain for stone tool manufacture given here (Table 1-12) is based upon a combination of ethnographic analogues and a great deal of recent experimental research. Muto (1971) distinguishes six steps in the manufacturing process: (1) selection of nodule or flake, (2) selection of fabricator, (3) removal of cortex from nodule, (4) thinning of the objective piece to the approximate section and cross-section, (5) securing of final outline and sections, (6) finishing of edge and hafting mechanism, if any (Muto 1971:43). The basic process outlined by Muto is corroborated by the experimental work of many researchers (e.g., Pond 1930; Crabtree 1967b, 1972; Stafford 1979). Knudson (1973) and House (1975) have produced more detailed analyses in which specific material outputs for each stage in the process are predicted. Knudson's model outlines the entire manufacturing sequence, while House's focuses on the finishing stages and on the use, breakage, and retouch of formed objects. Thus, the sequence of actions in our activity chain is a likely one. Until more is known about sources of raw material in the study area, however, the loctions of most of the proposed actions, and hence of most of the proposed output clusters (see Figure 1-16), must remain conjectural, and each segment includes several possible activity area locations.

Previous general research on quarry sites (Holmes 1890, 1919; Bryan 1950; Bryan and Tuohy 1960; Sharrock 1966) indicates that only preliminary forms of manufacturing, such as raw material extraction and the production of blanks and flakes suitable for further reduction, occur at the raw material source. It seems probable, however, that if raw materials are abundant near the planned place of utilization, flakes, chunks, cobbles, or nodules might be worked down to the desired form on the spot, bypassing the stage that would leave blanks and prepared cores as diagnostic indicators of the manufacturing sequence. "Rejects" diagnostic of the stage, however, might be found (Holmes 1890; Bryan 1950). If the source of raw materials is distant, requiring extended travel, some materials might be fully reduced for activity-specific use on that trip, while others are transported in rough form to the winter or summer village and reduced to final form as needed. If the source is accessible only through trade, the manufacturing stages represented in an archaeological assemblage will depend upon the form of the object (e.g., core, blank, finished product) when it was obtained.

The activity chain given here allows for collection of river-worn cobbles (e.g., basalt, quartzite), as well as short and extended trips to quarry sites, which take the form of either cobble/nodule concentrations (terrace surface/alluvium) or minable veins of siliceous material. Current environmental information indicates that no minable veins of raw material occur within that part of Zone I that lies within the scope of the Chief Joseph Dam Cultural Resources Project (Jermann et al. 1978). Hibbert (personal communication) has suggested that siliceous materials suitable for the manufacture of chipped stone tools are most likely to be found at contact zones between basalt flows, which would place these sources mainly on the left bank of the Columbia, probably in Zones IIL or IIL of the study region, where most known resources indeed do occur (see Salo, Appendix F; Key and Cavazos, Appendix G). In the activity chain and flow model given here, raw material is followed from the selection/extraction stage at either one of these two source locations through to the final finished product. It is then channeled into a utilization stage, at which point the sequence ends. For our purposes, the cycle of use, retouch, and reuse is not considered a part of the manufacturing sequence, except in the case of the tools used to quarry and to produce other tools.

Other Activity Chains

A number of additional activity chains must be completed before the entire system model can be articulated. The most important are dwelling and other architectural construction; production of domestic articles (e.g., snowshoes and cradle boards); collection, processing, and use of medicinal plants; and several ritual and social activities, all of which are required for modeling the complex patterning of summer and winter villages in Zone I. Abundant information for these chains is available in regional ethnogrphies. A variety of secondary chains, some of them based upon ethnographic analogues, can be constructed as necessary.

Model Expectation

The activity chains presented in the previous sections express test implications of the hunter-gatherer subsistence-settlement system recorded piecemeal in ethnographic literature. To condense these expectations and at the same time to make them more explicit, we have compiled a summary matrix of predicted outputs by activity area (Figure 1-17).

Activity areas at several levels of complexity are listed along the vertical axis of the matrix. Areas such as "lithic cache" may or may not be found within more inclusive areas such as "lithic workshop." However, we may expect to find both "lithic cache" and "lithic workshop" within spatial units at the level of "winter village" or "root camp." Hence, activity areas are grouped in this matrix according to inclusion within or association with "camps." "Spring village," however, does not include less complex activity areas. The only activity chain presented here that involves an action associated with the spring village is "root digging" (Table 1-10). Although Ray (1932) makes it clear that preparation for a root digging trip may take place at the spring village, he does not provide enough information about this preparation for us to posit a definable activity area within that spatial unit.

Expected outputs are listed along the horizontal axis of the matrix. These are grouped to isolate objects which are expected to exhibit wear patterns that indicate specific activities, objects distinctive of stone tool manufacture, archaeofaunal and archaeobotanical remains that owe their location to primary use as food, fuel, or building materials, and the like.

The expected outputs for a given activity area may be the result of a single action, or they may be the cumulative result of a number of actions. We expect, for example, that a butchering area in or near a hunt camp will include a variety of cutting and chopping implements which show wear from soft and hard materials, lithic debitage showing similar attributes of wear, an occasional broken projectile point, and a small amount of deer and/or elk bone, including cranial bone splinters. All of these result from a single (although perhaps repeated many times) action--"skin and butcher deer." The outputs in a meat drying area in this same camp, however, may include implements and debitage showing wear appropriate not only to cutting up meat and scraping bones but to building a drying rack. It should also include

EXPECTED OUTPUT ACTIVITY AREA	Cutting imp. soft (101)	Cutting imp. hard (102)	Chop. imp. soft (103)	Chop. imp. hard (104)	Scrape imp. soft (105)	Scrape imp. hard (106)	Piercing imp. (107)	Drill imp. soft (108)	Drill imp. hard (109)	Grind imp. soft (112)	Grind imp. hard (113)	Pound imp. soft (114)	Pound imp. hard (115)	Abrading imp. (116)	Wedge imp. soft (117)	Wedge imp. hard (118)	Percus. flak. imp. (119)	Pres. flak. imp. (120)	Anvil (121)	Lithic debitage (199)
Hearth area (WV)	●	●		●			●						●	●				●		●
Earth oven (WV)																				
Butchering area (WV)	●	●		●																●
Meat drying area (WV)	●			●		●							●		●					●
Skin dressing area(WV)	●			●	●	●	●													
Storage area (WV)																				
Bone deposit area (WV)																				
Lithic workshop (WV)													●	●		●	●	●	●	●
Lithic cache (WV)	●	●	●	●	●	●	●	●	●				●	●		●	●	●	●	
Nearby storage (WV)																				
Hearth area (SV)																				
Fish drying area (SV)	●						●													●
Woodworking area (SV)	●			●		●														●
Lithic workshop (SV)													●	●		●	●	●	●	●
Lithic cache (SV)	●	●	●	●	●	●	●	●	●				●	●		●	●	●	●	
Spring village	●	●					●							●				●		●
Hearth area (TC)																				●
Hearth area (RC)	●																			●
Earth oven (RC)																				
Root drying area (RC)	●				●		●				●	●								●
± Lithic workshop (RC)				●		●							●	●		●	●	●	●	●
Hearth area (HC)	●			●									●							●
Butchering area (HC)	●	●		●																●
Meat drying area (HC)	●			●		●	●						●		●					●
± Lithic workshop (HC)				●		●							●	●		●	●	●	●	●
Salt lick																				
Hearth area (QC)																				
Litnic workshop (QC)				●		●							●	●		●	●	●	●	●
Cache (QC)													●	●			●	●	●	
Quarry workshop				●		●							●	●		●	●	●	●	●
Quarry cache				●		●							●	●		●	●		●	
Hearth area (BC)																				
Lithic workshop (BC)													●	●			●	●	●	●
Cache (BC)													●	●			●	●	●	
Outcrop workshop													●	●			●	●	●	●
Outcrop cache													●	●			●	●	●	

EXPECTED OUTPUT ACTIVITY AREA	Proj. pt. whole (201)	Proj. pt. broken (202)	Bone point (203)	Horn socket (204)	Unmod. cobbles (301)	Unmod. nodules (302)	Usable chunk (303)	Unusable chunk (304)
Hearth area (WV)					●		●	
Earth oven (WV)								
Butchering area (WV)		●						
Meat drying area (WV)								
Skin dressing area(WV)								
Storage area (WV)								
Bone deposit area (WV)								
Lithic workshop (WV)							●	●
Lithic cache (WV)	●				●	●	●	
Nearby storage (WV)								
Hearth area (SV)					●		●	
Fish drying area (SV)								
Woodworking area (SV)								
Lithic workshop (SV)							●	●
Lithic cache (SV)	●				●	●	●	
Spring village								
Hearth area (TC)					●			
Hearth area (RC)					●		●	
Earth oven (RC)					●			
Root drying area (RC)								
± Lithic workshop (RC)							●	●
Hearth area (HC)					●		●	
Butchering area (HC)		●						
Meat drying area (HC)								
± Lithic workshop (HC)							●	●
Salt lick								
Hearth area (QC)								
Litnic workshop (QC)							●	●
Cache (QC)							●	
Quarry workshop							●	●
Quarry cache							●	
Hearth area (BC)							●	
Lithic workshop (BC)							●	●
Cache (BC)					●	●	●	
Outcrop workshop							●	●
Outcrop cache					●	●	●	

EXPECTED OUTPUT ACTIVITY AREA	Prepared core (401)	Prim. decort. flk. (402)	Sec. decort. flk. (403)	Tertiary flake (404)	Bipolar flake (405)	Broken core (406)	Whole formed obj. (407)	Lg. quarry flake (408)	Pressure flake (409)	Exhausted core (411)	Tool blank (412)	Broken formed obj. (413)	Heat spall (414)	"Crazing" (415)
Hearth area (WV)	●					●	●	●			●	●	●	●
Earth oven (WV)														
Butchering area (WV)														
Meat drying area (WV)														
Skin dressing area(WV)														
Storage area (WV)														
Bone deposit area (WV)														
Lithic workshop (WV)	●	●	●	●	●	●	●	●	●	●	●	●		
Lithic cache (WV)	●						●	●			●			
Nearby storage (WV)														
Hearth area (SV)	●					●	●	●			●	●	●	●
Fish drying area (SV)														
Woodworking area (SV)														
Lithic workshop (SV)	●	●	●	●	●	●	●	●	●	●	●	●		
Lithic cache (SV)	●						●	●			●			
Spring village														
Hearth area (TC)														
Hearth area (RC)	●					●	●	●			●	●	●	●
Earth oven (RC)														
Root drying area (RC)														
± Lithic workshop (RC)	●	●	●	●	●	●	●	●	●	●	●	●		
Hearth area (HC)	●					●	●	●			●	●	●	●
Butchering area (HC)														
Meat drying area (HC)														
± Lithic workshop (HC)	●	●	●	●	●	●	●	●	●	●	●	●		
Salt lick														
Hearth area (QC)	●					●	●	●			●	●	●	●
Litnic workshop (QC)	●			●	●	●	●	●	●	●	●	●		
Cache (QC)														
Quarry workshop	●			●	●	●	●	●	●	●	●	●		
Quarry cache														
Hearth area (BC)	●					●	●				●	●	●	●
Lithic workshop (BC)	●	●	●	●	●	●	●		●	●	●	●		
Cache (BC)														
Outcrop workshop		●	●	●	●	●	●		●	●	●	●		
Outcrop cache														

EXPECTED OUTPUT ACTIVITY AREA	Deer/elk bone (601)	Antelope bone (602)	Mammal bone (603)	Long bone splinter (604)	Cran. bone splint. (605)	Fish bone (606)	Mussel shell (608)	Charred wood, any (701)	Charred wood, spe. (702)	Charred root (703)	Charred frt. seeds (704)	Charred veg. seeds (705)	Charred lvs./stems (706)	Charred moss (707)
Hearth area (WV)				●		●		●	●	●	●	●		●
Earth oven (WV)									●				●	●
Butchering area (WV)	●				●									
Meat drying area (WV)									●					
Skin dressing area(WV)								●						
Storage area (WV)														
Bone deposit area (WV)	●					●								
Lithic workshop (WV)														
Lithic cache (WV)														
Nearby storage (WV)														
Hearth area (SV)						●		●	●	●	●	●		
Fish drying area (SV)						●								
Woodworking area (SV)														
Lithic workshop (SV)														
Lithic cache (SV)														
Spring village														
Hearth area (TC)								●						
Hearth area (RC)								●		●				
Earth oven (RC)									●	●			●	
Root drying area (RC)														
± Lithic workshop (RC)														
Hearth area (HC)				●				●	●		●			
Butchering area (HC)	●				●									
Meat drying area (HC)									●					
± Lithic workshop (HC)														
Salt lick														
Hearth area (QC)								●						
Litnic workshop (QC)														
Cache (QC)														
Quarry workshop														
Quarry cache														
Hearth area (BC)								●						
Lithic workshop (BC)														
Cache (BC)														
Outcrop workshop														
Outcrop cache														

EXPECTED OUTPUT ACTIVITY AREA	Talus depression (801)	Lg. soil depress. (802)	Sm. soil depress. (803)	Post mold (804)	Rock alignment (805)	Large flat rocks (806)	Burnt soil (810)	Fire-cracked rock (811)
Hearth area (WV)			●				●	●
Earth oven (WV)		●					●	●
Butchering area (WV)								
Meat drying area (WV)				●			●	●
Skin dressing area(WV)			●	●			●	●
Storage area (WV)		●		●		●		
Bone deposit area (WV)								
Lithic workshop (WV)								
Lithic cache (WV)								
Nearby storage (WV)	●							
Hearth area (SV)							●	●
Fish drying area (SV)								
Woodworking area (SV)								
Lithic workshop (SV)								
Lithic cache (SV)								
Spring village								
Hearth area (TC)							●	●
Hearth area (RC)							●	●
Earth oven (RC)		●					●	●
Root drying area (RC)								
± Lithic workshop (RC)								
Hearth area (HC)			●				●	●
Butchering area (HC)								
Meat drying area (HC)				●			●	●
± Lithic workshop (HC)								
Salt lick		●			●			
Hearth area (QC)							●	●
Litnic workshop (QC)								
Cache (QC)								
Quarry workshop								
Quarry cache								
Hearth area (BC)							●	●
Lithic workshop (BC)								
Cache (BC)								
Outcrop workshop								
Outcrop cache								

Figure 1-17. Expected outputs within activity areas as predicted by activity chain models.

post molds and an area of charred wood, burnt soil, and fire-cracked rock. These result from a series of separate kinds of actions performed in the same area.

It should be re-emphasized at this point that this matrix is not a complete description of expected clusters; it is an example. A complete matrix awaits additional environmental information, the construction of additional chains, and the definition of output classes in terms of modes of an archaeological artifact classification system. In the matrix as given here, those clusters expected to occur outside the winter or summer village (e.g., "butchering area, hunt camp") can be considered relatively complete except for changes that may be made in response to additional ethnographic or environmental information and changes that will necessarily occur when output classes are specified in more detail. The descriptions of areas such as "hearth area, winter village," however, will grow more elaborate as outputs from additional chains are specified.

Once defined, activity areas at any level of complexity may be displayed by physiographic zone and habitat type association. In Figure 1-18, we have chosen to display activity areas at the level of "hearth area" and "butchering area" in this way. It is immediately clear from this matrix that most output clusters of all kinds are expected to occur in or near three or four habitat types: (1) the Broadleaf Tree Over Shrub and Coniferous and Broadleaf Tree Over Shrub environments on both sides of the river in Zone I and II; (2) these two plus the Coniferous Tree Over Shrub environments in Zone IIIR; and (3) those already listed plus the Coniferous Forest habitat types. It is also clear that during fall and winter most clusters other than those in Zone I are expected to occur on the right bank of the river. These largely represent hunting and berrying activities, although some outputs from fall root digging may also occur. Again, however, lithics manufacturing and cache areas are the exception. Until more is known about sources of raw materials for lithics manufacture, we must assume the possibility of quarry trips to Zone IIL and perhaps Zone IIIL during the spring, summer, and fall. It should be noted that the omission of antelope hunting, an activity sequence that has yet to be constructed, creates a significant bias in the matrix as it now stands, since antelope hunting implies camps and butchering areas in Zone IIIL during the fall.

Key to Habitat Types

IS = Island
RP = Riparian
SS = Shrub Steppe
MV = Macrophyllous Vine and Shrub
RL = Rockland
RK = Rock
BS = Broadleafed Tree over Shrub
CB = Coniferous and Broadleafed Tree over Shrub
CS = Coniferous Tree over Shrub
CF = Coniferous Forest

Key to Seasons

1 = Spring
2 = Early Summer
3 = Late Summer
4 = Fall
5 = Winter

Figure 1-18. Expected locations of activity areas within physiographic zones.

ZONE		ACTIVITY AREA																							
		Clustered:	Hearth - all foods	Hearth - roots highest	Hearth - berries highest	Hearth - deer/elk highest	Hearth - fish highest	Hearth - few foods	Butchering area	Meat drying area	Fish drying area	Root drying area	Skin dressing area	Storage area	Bone deposit area	Lithics workshop	Lithics cache	Woodworking area	Earth oven	*Dispersed:*	Projectile points	Woodworking tools	Cutting tools (101)	*Complex areas:*	Not modeled
ZONE *IV*	IS																								
	RP																								
	SS																								
	MV								3,4												3,4	3,4			
	RL								3,4																
	RK																								
	BS				3	3,4		3,4	3,4	3,4					3,4			3,4	3,4		3,4	3,4			
	CB				3	3,4		3,4	3,4	3,4					3,4			3,4	3,4		3,4	3,4			
	CS				3	3,4		3,4	3,4	3,4					3,4			3,4	3,4		3,4	3,4			
	CF				3	3,4		3,4	3,4	3,4					3,4			3,4	3,4		3,4	3,4			
ZONE *IIIR*	IS																								
	RP																								
	SS																								
	MV								3,4												3,4	3,4			
	RL								3,4																
	RK																								
	BS				3	3,4		3,4	3,4	3,4					3,4			3,4	3,4		3,4	3,4			
	CB				3	3,4		3,4	3,4	3,4					3,4			3,4	3,4		3,4	3,4			
	CS				3	3,4		3,4	3,4	3,4					3,4			3,4	3,4		3,4	3,4			
	CF																					3,4			
ZONE *IIR*	IS																								
	RP																								
	SS																								
	MV								3,4												3,4	3,4			
	RL								3,4																
	RK																								
	BS				3	3,4		3,4	3,4	3,4					3,4	1,2,3	1,2,3	5			3,4	3,4			
	CB				3	3,4		3,4	3,4	3,4					3,4	1,2,3	1,2,3	5			3,4	3,4			
	CS																					3,4			
	CF																					3,4			
ZONE *I*	IS																								
	RP																				5	5			
	SS		5		2,3	3,4	2,3	5	1,3,4	3,4	2		5	5	5	5	5	5	5		5				
	MV																				5	5			
	RL																				5				
	RK													5							5				
	BS		5		2,3	3,4	2,3	5	1,3,4	3,4	2		5	5	5	5	5	5	5		5	5			
	CB		5		2,3	3,4	2,3	5	1,3,4	3,4	2		5	5	5	5	5	5	5		5	5			
	CS		?																		5	5			
	CF																				5	5			
ZONE *IIL*	IS																								
	RP																								
	SS																						1		
	MV																					1,3			
	RL																						1		
	RK																						1		
	BS				1				1,2,3				1			1,2,3	1,2,3	1,2,3	1			1,3	1		
	C9				1				1,2,3				1			1,2,3		1,2,3	1			1,3	1		
	CS																					1,3	1		
	CF																					1,3	1		
ZONE *IIIL*	IS																								
	RP																								
	SS																								
	MV																								
	RL																								
	RK																								
	BS								1,2,3													3			
	CB								1,2,3													3			
	CS																								
	CF																								

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SECTION II: ENVIRONMENTAL HISTORY

When the project began, very little paleoenvironmental data pertaining specifically to the project area was available. Sedimentary data and faunal and macrobotanical assemblages from our excavations would aid in environmental reconstruction, but would not be sufficient alone. Two projects, a geomorphological study by Hibbert, and a palynological study by Dalan, were instigated to collect paleoenvironmental information specific to the project area.

In order to provide a history of the landscape in the project area, Hibbert undertook a geomorphological study of the trench of the Columbia River from Chief Joseph Dam upstream to River Mile 590, and of nearby areas important to understanding the genesis of local landforms. His paper, originally completed in 1980 and revised in 1984, is included here as Chapter 2. He discusses the Quaternary history of the project area, integrating field evidence and radiocarbon dates with broader regional interpretations of glacial and postglacial events.

Like the majority of geomorphological studies in the Plateau, Hibbert concentrates primarily on description and interpretation of the catastrophic and large-scale events of the Pleistocene, and touches only briefly on depositional processes and landform development in the Holocene. His material provides the historical background for understanding the characteristics of the landscape, geomorphology, and local river hydrology during the period of time our sites were occupied. For example, the entrenchment of the modern Columbia River in its deep valley, a major factor influencing modern river hydrology and deposition, is a consequence of Pleistocene and earlier geologic history. Nonetheless, archaeologists are typically interested in geomorphological reconstruction at a much finer geographic scale than commonly pursued by geomorphologists. The detailed stratigraphic information obtained from the excavation of sites by this project, with the large number of radiocarbon dates and dates based on stylistic attributes, enables us to contribute additional detail to the regional geochronological history. Chapter 5, by Campbell, summarizes data from excavated sites and relates this data to regional paleoenvironmental reconstruction.

Pollen analysis is a widely-used method for obtaining paleoenvironmental information, particularly concerning vegetation and climate. Of the limited number of pollen studies that had been done in eastern Washington by 1978, none were in the immediate vicinity of the project area, and the project sought to obtain a pollen profile from a lake in or near the project area. Dalan collected cores from two other lakes before finding a well-preserved, relatively complete Holocene sequence from Goose Lake. Her analysis of the Goose Lake core, included as Chapter 3 was written in 1979 before radiocarbon dates had been obtained for the core.

Nickmann and Leopold, interested in the stabilization of vegetation in the early Holocene and in the effects of Mazama tephra on the vegetation, later reanalyzed the lower portion of the core. They sampled the lower portion of the core at finer intervals and obtained radiocarbon age determinations. Their paper, which presents evidence for an early Holocene cooling, is included as Chapter 4.

Dalan's brief report on the Rex Grange core is included as Appendix C because the core covers the historic period and may be of use in future research on the late prehistoric and historic periods. The exact timing and extent of vegetation disturbance due to introduction of domestic animals has not been adequately explored. Chatters (1982) used pollen analysis and other paleoenvironmental indicators in his interpretation of historic period homesteading of the Pahsimeroi Valley, Idaho. Certainly the disturbance recorded in the Rex Grange core, as well as in most other cores which have been analyzed, provides a warning of the pitfalls in reconstructing vegetation from historic observations.

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2. QUATERNARY GEOLOGY AND THE HISTORY OF THE LANDSCAPE ALONG THE COLUMBIA BETWEEN CHIEF JOSEPH AND GRAND COULEE DAMS

by Dennis M. Hibbert

This study provides a history of the landscape encompassed by the Chief Joseph Dam Cultural Resources Project, an area extending from Chief Joseph Dam River Mile (RM) 545 along Rufus Woods Lake (the Columbia River) to approximately RM 590 about 4.5 miles downstream from Grand Coulee Dam. The surfaces and river banks in the Columbia River Canyon were examined and mapped to determine when the canyon surfaces that carry evidence of human habitation were formed. In addition, the large drainages coming into the Columbia from the north were investigated for the record they contain of the late-Wisconsin (late Pleistocene) recession of the Okanogan Lobe of the Cordilleran Ice Sheet. An associated goal of this study was to locate source areas of lithic material recovered from the archaeological sites in the Chief Joseph Dam Project area. The results of this search are recorded in Appendix I.

CONVENTIONS

Since the study area is quite large, it has been convenient to indicate distances with the help of section lines and river miles as marked along the Columbia River Canyon on the standard U.S. Geological Survey 15' topographic base maps. Consequently, distances in this report are given in miles. For consistency, all references to length and elevation are in English measures to conform to the 15' base maps. These four base maps are: Bridgeport (1957), Boot Mountain (1950), Alameda Flat (1950), and Nespelem (1950). Features visible from the river are referred to by their river mileage (e.g. RM 553). Other features are located acccording to the section-township-range system unless related to locations prominently named on the base quadrangles. For the purposes of this report, "Omak Trench" refers to the large trough that runs from RM 568 north almost to Omak; Goose Lake and Omak Lake are in the Trench. The "upper canyon" indicates the portion of the Columbia Canyon upstream from the mouth of the Omak Trench; the "lower canyon" indicates the portion downstream from the Omak Trench. Although the dammed portion of the Columbia within the Chief Joseph Dam Cultural Resources Project area is now called Rufus Woods Lake, the river and its canyon will be called by their more traditional names, the "Columbia River" and the "Columbia River Canyon," in this report. Figure 2-1 (seven consecutive maps) shows the major geologic features between Chief Joseph Dam and Grand Coulee Dam that are described in this report.

LEGEND

Holocene

- △ Postglacial Slumps
- ○ Recent Alluvial Fans
- ⁘ Columbia River Gravel

Pleistocene

- ▩ Coarse Gravel Above (?) Till
- ▤ Nespelem Silt (mostly Sand)
- ░ Glacial Outwash (mostly Gravel and Sand)
- ▧ Ice-contact Stratified Drift
- ▤ Glacio-lacustrine Clay and Silts
- ⁖ Glacial Till
- ▫ Large Erratics
- ■ Dump-moraine or Debris Flow
- ▩ Coarse Gravel
- ▒ Coarse Sand

Pre-Pleistocene

- ▦ Columbia River Basalts
- ✛ Pre-Cenozoic Gneisses and Granitic Rocks

• River Mile

Water surface at 946′

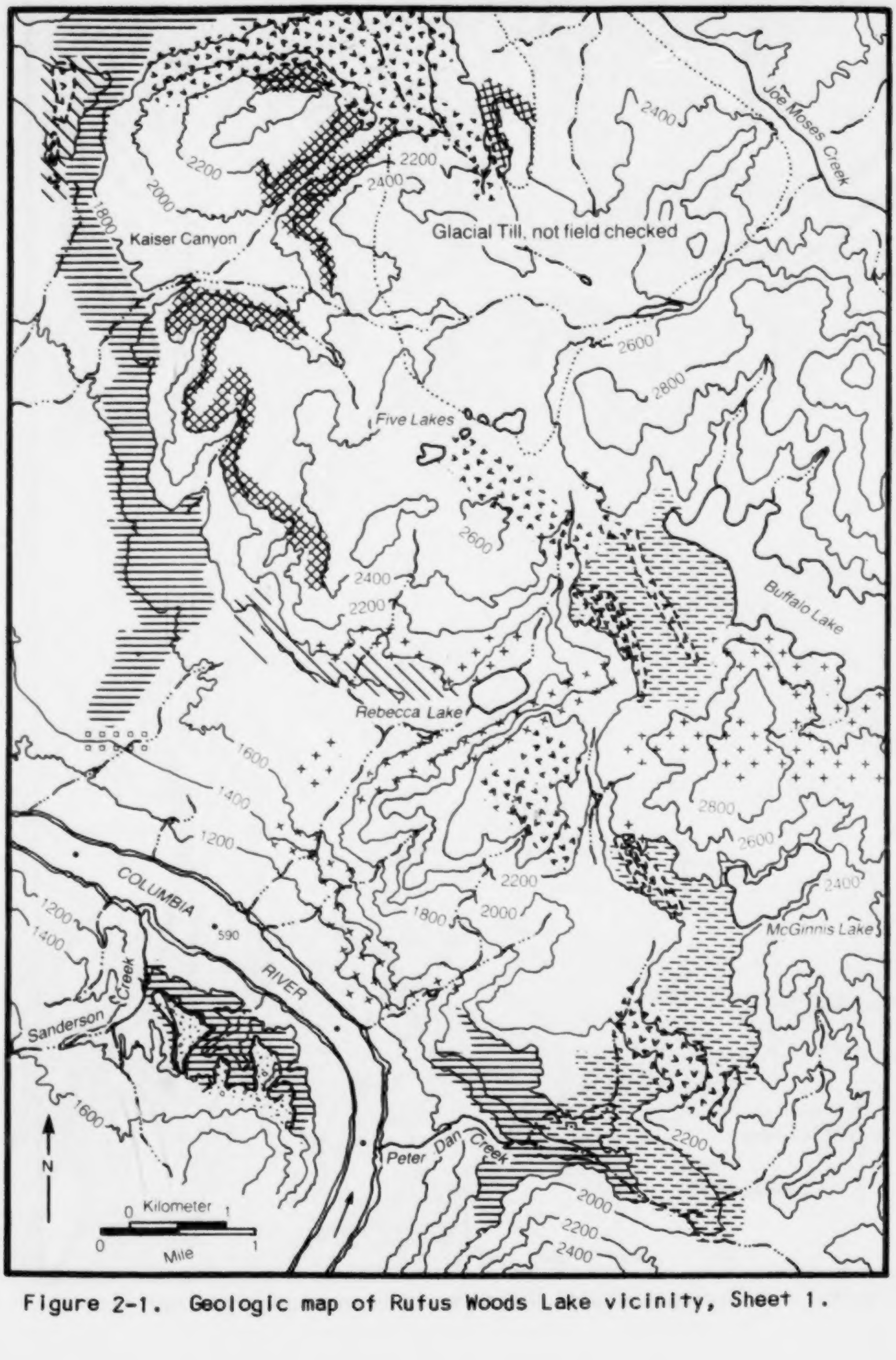
Joe Moses Creek
2400
2200
2400
2200
2000
1800
Kaiser Canyon
Glacial Till, not field checked
2600
2800
Five Lakes
2600
2400
2200
Buffalo Lake
Rebecca Lake
1600
1400
1200
2800
2600
2200
2400
2000
1800
McGinnis Lake
COLUMBIA
RIVER
590
1200
1400
Sanderson
Creek
1600
Peter
Dan
Creek
2200
2000
2200
2400
N
0 Kilometer 1
0 Mile 1

Figure 2-1. Geologic map of Rufus Woods Lake vicinity, Sheet 1.

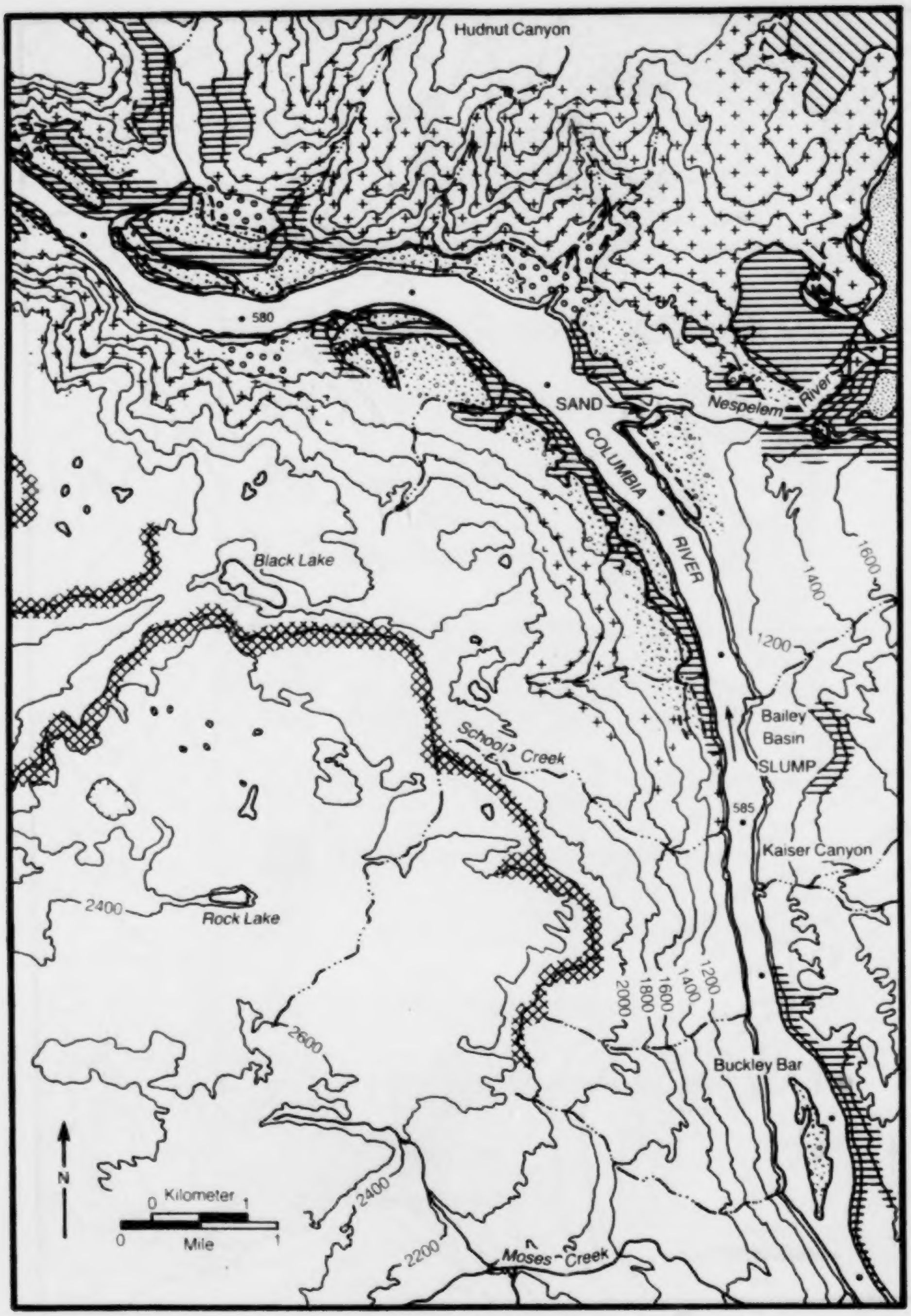
Hudnut Canyon
580
SAND
COLUMBIA
RIVER
Nespelem
River
1600
1400
1200
Black Lake
Bailey
Basin
SLUMP
585
School
Creek
Kaiser Canyon
2400
Rock Lake
2000
1800
1600
1400
1200
Buckley Bar
2600
N
0 Kilometer 1
0 Mile 1
2400
2200
Moses Creek

Figure 2-1. Geologic map of Rufus Woods Lake vicinity, Sheet 2.

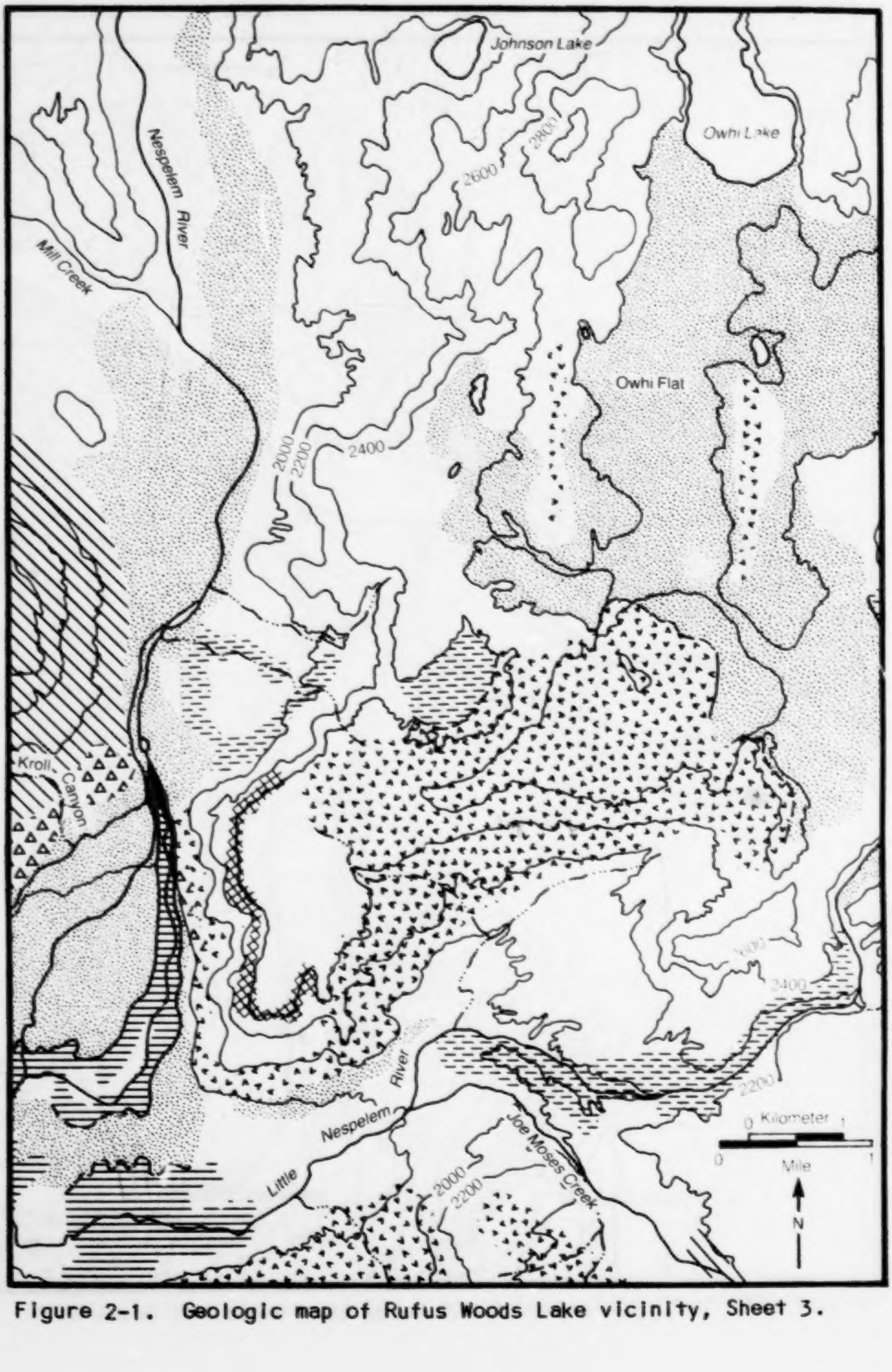
Johnson Lake
Owhi Lake
Nespelem River
Mill Creek
2600
2800
Owhi Flat
2000
2200
2400
Kroll Canyon
2800
2400
2200
River
Little Nespelem
Joe Moses Creek
2000
2200
0 Kilometer 1
0 Mile 1
N

Figure 2-1. Geologic map of Rufus Woods Lake vicinity, Sheet 3.

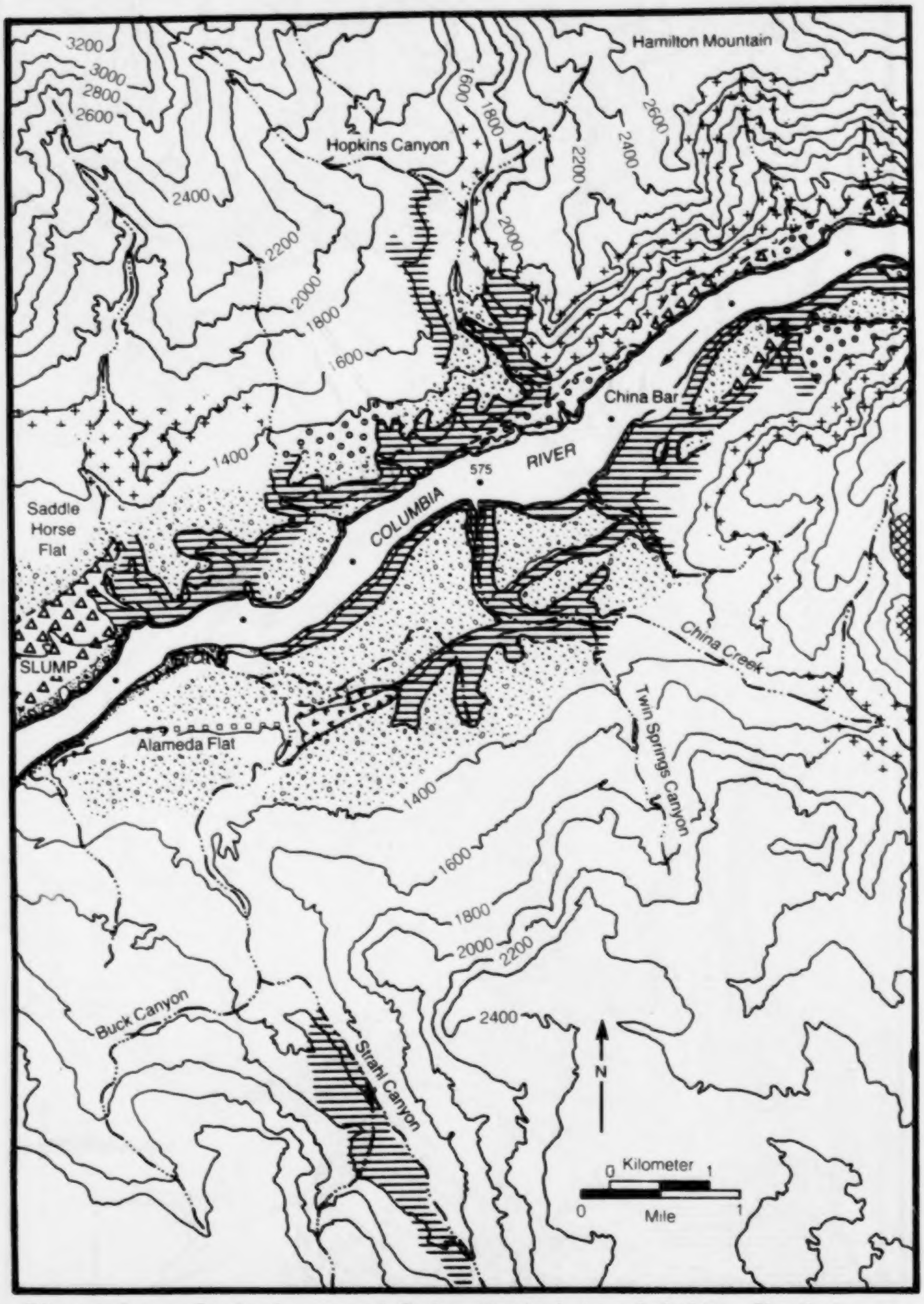
Hamilton Mountain
3200
3000
2800
2600
2400
Hopkins Canyon
1600
1800
2000
2200
2400
2600
2200
2000
1800
1600
1400
China Bar
575
RIVER
COLUMBIA
Saddle
Horse
Flat
SLUMP
Alameda Flat
China Creek
Twin Springs Canyon
1400
1600
1800
2000
2200
2400
Buck Canyon
Strahl Canyon
N
Kilometer
0
1
Mile
0
1

Figure 2-1. Geologic map of Rufus Woods Lake vicinity, Sheet 4.

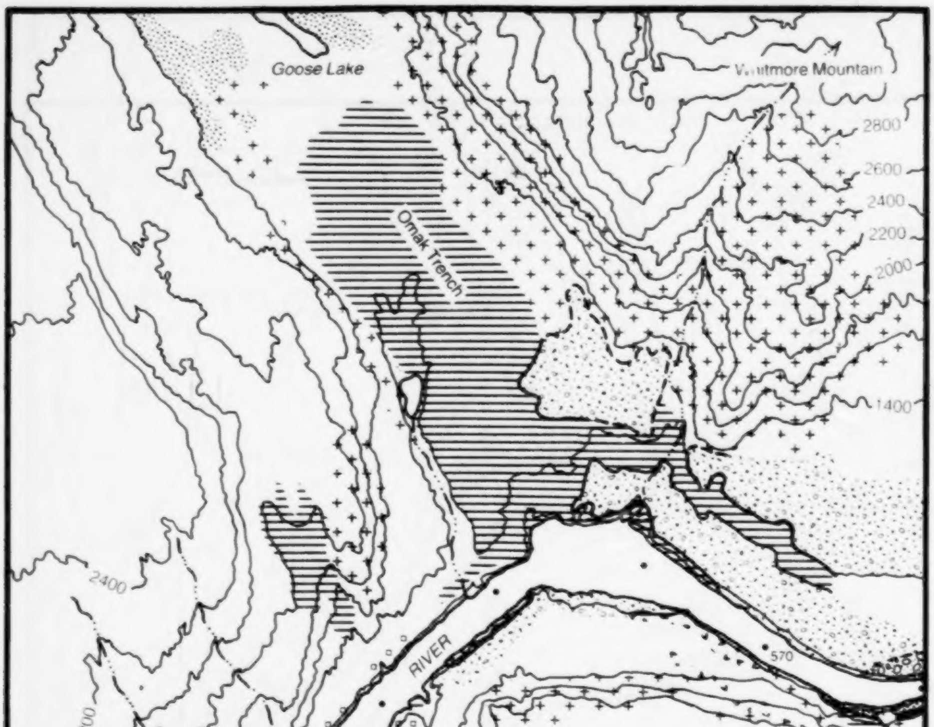
Goose Lake
Whitmore Mountain
2800
2600
2400
2200
2000
1400
Omak Trench
2400
2200
RIVER
COLUMBIA
570
1400
1600
1800
2000
2200
2400
565
2000
1800
1600
1400
1200
Alec Canyon
0 Kilometer 1
0 Mile 1
N

Figure 2-1. Geologic map of Rufus Woods Lake vicinity, Sheet 5.

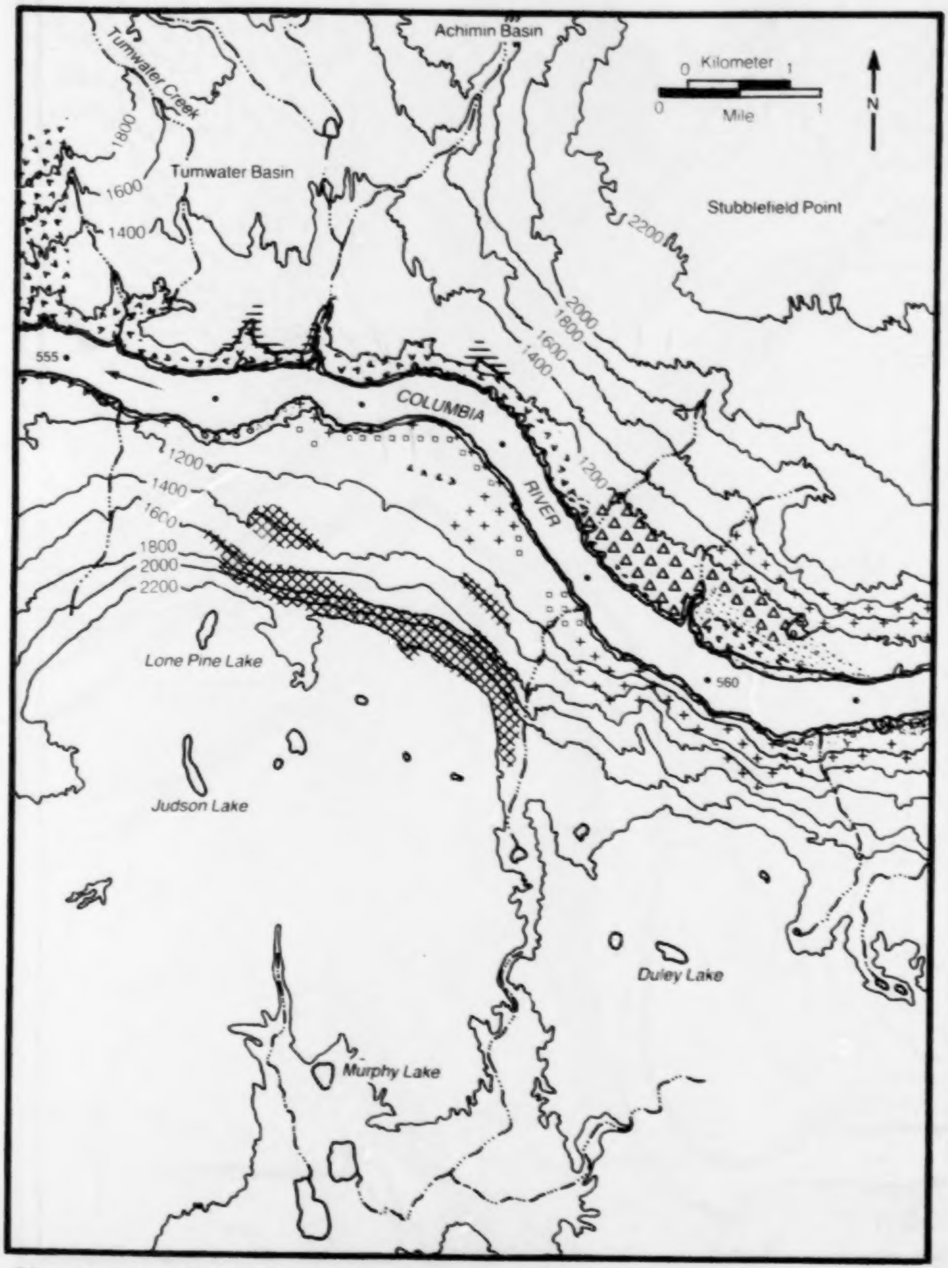
Achimin Basin
Tumwater Creek
Tumwater Basin
0 Kilometer 1
0 Mile 1
N
Stubblefield Point
1800
1600
1400
2200
2000
1800
1600
1400
1200
555
COLUMBIA
RIVER
1200
1400
1600
1800
2000
2200
560
Lone Pine Lake
Judson Lake
Duley Lake
Murphy Lake

Figure 2-1. Geologic map of Rufus Woods Lake vicinity, Sheet 6.

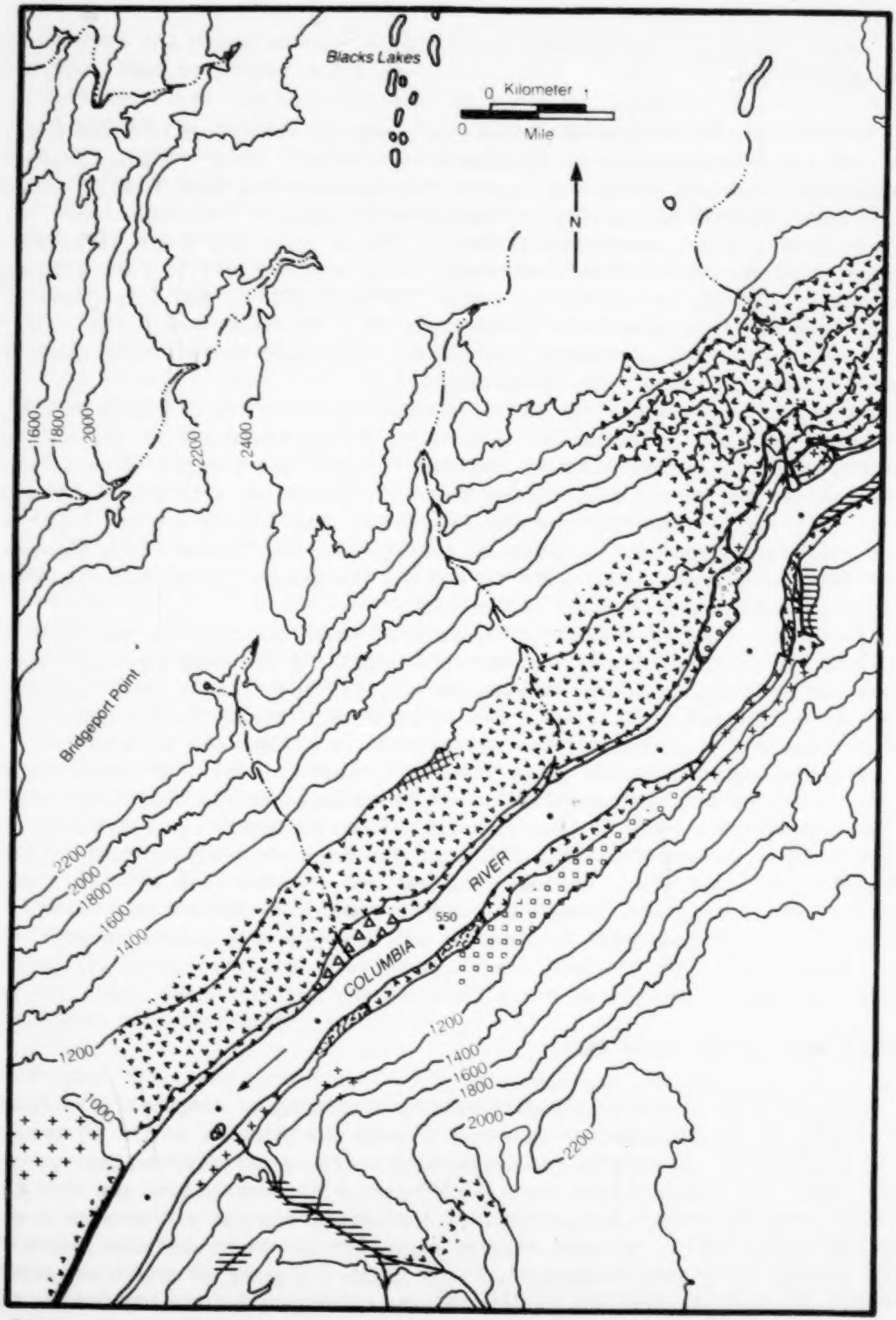
Blacks Lakes
0 Kilometer 1
0 Mile
N
1600
1800
2000
2200
2400
Bridgeport Point
2200
2000
1800
1600
1400
1200
1000
550
COLUMBIA
RIVER
1200
1400
1600
1800
2000
2200

Figure 2-1. Geologic map of Rufus Woods Lake vicinity, Sheet 7.

AREAL DESCRIPTION

The Columbia River skirts the northern edge of the Columbia River Basalts southward from the mouth of the Spokane River. There, after flowing south from Canada, the river turns west toward the mouth of the Omak Trench, where it cuts into the Plateau basalts to emerge at Bridgeport, the downriver boundary of the Chief Joseph Dam project. The canyon's south rim is basalt. Upstream from the Omak Trench, the north rim is mostly granitic rock although some basalt is found north of the river. Pardee (1918) called this granitic rim rock the Colville Batholith. Downstream from the Omak Trench the north rim is basalt; in this portion of the canyon, the basalt/crystalline contact generally lies above the 1,800 ft level.

The Omak Trench itself may be the former course of the Columbia around the Plateau basalts. A feature which extends across Alameda Flat and Saddle Horse Flat, and is continuous with the Omak Trench, was thought to be a flood-cut channel in the canyon fill during the early phases of this study. I now believe it to be a former part of the Columbia's channel, before the river was pushed south by advancing ice sometime during the Pleistocene. This feature is cut into bedrock and lined with till as is the present river bed (see Pre-Quaternary Stratigraphy below).

In the Chief Joseph Project area, several watercourses from the north drain into the Columbia River; the most prominent are the Nespelem and Little Nespelem Rivers, Coyote Creek, Hopkins Canyon, the Omak Trench, and Tumwater Basin. There is permanent flow in the first three. Strahl Canyon and China Creek are the major drainages from the Waterville Plateau to the south.

Upstream from the Omak Trench, prominent, nearly level, and discontinuous terraces line the canyon from river level to an elevation of 1,800 ft. Higher terrace remnants are found in side canyons. Some particularly prominent surfaces lie at elevations near 1,800 ft, (the Nespelem silt terrace), 1,400 and 1,240 ft (Flint, 1935). Terrace surfaces are covered with alluvial fans; on many of the lower ones, layers of river gravel underlie the fans. In general, all but the youngest surfaces in the study area are covered with loess. Downstream from the Omak Trench, a surface is developed on till, bedrock, and coarse gravels at elevations varying between 1,100 and 1,200 ft.

PREVIOUS WORK IN THE STUDY AREA

Pardee (1918) did reconnaissance geologic mapping of the Colville Indian Reservation, which includes the Okanogan County (north) bank of the Columbia in the study area. He mapped two Quaternary units--glacial drift (till, gravel, and silt) and Nespelem silt (silt mixed with some gravel and sand). He named these formations and maintained that they recorded a time when sea level was much higher. In later studies along the Columbia, between the mouth of the Spokane River and Bridgeport, Flint (1935, 1936; Flint and Irwin 1939) described the glacial features of the region, noting that ice lingered in the valleys after melting off the highlands. He thought ice never covered the ridge between the Nespelem and Sanpoil river valleys but did extend south beyond the ridge both east and west.

Flint described the Nespelem silt as material deposited in a lake with a till and preglacial deposit floor. This lake, called Glacial Lake Columbia in this report, formed when the Columbia Canyon below the Grand Coulee was blocked by the late-Wisconsin Okanogan Lobe of the Cordilleran Ice Sheet and the Columbia flowed out through Grand Coulee. As the ice melted, this lake extended down the canyon and lacustrine sediments were deposited farther downstream from Grand Coulee. Flint suggested that after the river abandoned Grand Coulee and reoccupied its lower channel, a series of terraces was cut from the lake fill, including a terrace graded to the ice-marginal Great Terrace of the Columbia at a point opposite Bridgeport.

Flint failed to note that the surfaces he called terraces downstream from the Omak Trench are developed almost completely in till and are therefore not continuations of the upper-canyon terraces. Nor do those terraces he describes in the upper canyon generally occur between the mouth of the Omak Trench and Bridgeport. Since his lower-canyon surface is not continuous with the Great Terrace, it is not necessarily cogenetic with it.

At the site of Grand Coulee Dam, Flint and Irwin described a "basal sequence of predominantly glacial varved silt and clay, overlain by...an intermediate zone of till and associated poorly stratified silt, sand, and gravel overlain by...stratified glacial-lacustrine silt and glaciofluvial sand and gravel" (1939:665). The latter corresponds to Pardee's Nespelem silt. On the north bank of the river at this location, the till is overlain by approximately 200 ft of deltaic deposits. Flint and Irwin described areal relationships and occurrences of these units and the series of terraces composed of them, but published no detailed maps. W.L. Peterson mapped Quaternary sediments around Bailey Basin and at Alameda Flat as part of a study of landslides along the Columbia (Jones et al. 1961), and the U.S. Army Corps of Engineers published a map (1971) of the shoreline geology along the reservoir between Chief Joseph Dam and Grand Coulee Dam. The area covered by those various maps extends no more than an average of 300 yd from the river. In the present study, this mapping was extended to the canyon rim where feasible.

STRATIGRAPHY: PRE-QUATERNARY

Pardee's "Colville Batholith" is regional bedrock (or basement rock) in the part of Washington state which includes the study area. The oldest rock in the north of the western and central parts of the study area is gneiss, a high-grade metamorphic rock currently thought to be more than a billion years old in this region. Several granitic intrusives of Cretaceous and early Tertiary age are the bedrock in the central and eastern parts of the study area (Staatz and Morris 1976). The next oldest material in the study area is the Latah Formation of middle-Miocene age (as the term is used by Swanson and Wright 1978). In the canyon, the Latah consists of flat-lying, well-bedded fine sandstones and siltstones, grey to light brown, stained with ferric iron and containing abundant muscovite. It is richly fossiliferous, containing stem and leaf impressions of deciduous plants. The Latah is interbed material in the Columbia River Basalts, and comprises pond and lake deposits formed in landscapes later buried under basalt. In this section of the canyon, basalts older than the Latah are not found, so the Latah rests directly on granitic bedrock.

STRATIGRAPHY: QUATERNARY

More recent deposits in the study area are Pleistocene and Holocene in age. Many of these are associated with the advance and retreat of the Okanogan Lobe of the Cordilleran ice sheet, described in greater detail in the concluding section (Cenozoic History of the Region) of this report. The oldest Quaternary unit seen by this investigator is a rhythmically bedded, light-tan silt lacking the abundant fossil material and muscovite which characterizes Latah silts. It was found as clasts in very coarse flood gravels that underlie till left by the Okanogan Lobe opposite Brandts Landing (RM 553). These silts are similar to later silts laid down when the Lobe dammed the river and they may reflect an earlier ice advance. Other clasts found in the flood gravels are peat and diatomite that are probably derived from Latah interbeds in the basalts.

The coarse gravels are found along the Douglas County (south) bank of the river between RM 553 and RM 549, from below river level to nearly 1,100 ft. They are openwork gravels foreset down the canyon and containing rounded clasts up to four ft in intermediate diameter. The smallest clasts are ten inches in intermediate diameter; many have clayey coatings. Foresets dip at approximately 20°. In addition to the peats, diatomite and silts mentioned above, lithologies commonly include basalt and granitic rock, cherts of various colors, light-brown quartzites, metamorphosed rocks of basic composition, and some volcanics. The sources of the metamorphics and volcanics must lie upstream from the mouth of the Grand Coulee, as such rocks are not exposed near the canyon in the study area.

Very coarse sands are found at the same stratigraphic position on the south bank of the river between RM 571 and 570, 565.5 and 562. They underlie till between RM 565 and 566; on the north bank they are found between RM 564 and 563. They are similar to the gravels and probably have the same origin. Between RM 565 and 564, the sands are cross-bedded on a scale approaching an eighth of a mile; the river cuts across the axis of the crossbeds. The sands on the south bank are exposed from below river level to nearly 1,400 ft between RM 565 and 563, and up to 1,000 ft at the other localities.

MASSIVE DUMP-MORAINE OR DEBRIS-FLOW DEPOSITS

Massive dump moraine deposits overlie the very coarse sands where the top of the sands is visible. A good exposure of this material is on the south bank between RM 570 and 571 where one section is 200 ft thick. There, basalt and granitic basement rock, peat, and chunks of Latah material, more than 70 ft in length, are contained in an iron-stained matrix derived from the Latah and rich in quartz, orthoclase, muscovite, biotite, and diatomite. The size of the friable pieces of Latah and peat (the latter sometimes several yards long) indicates that they have not been transported far; they may originate from the canyon walls above. Silty peat from this material has yielded a radiocarbon date of 30,540±3110 B.P. (TX-3802) (Table 2-1). This peat is in a 10-15 ft layer in the north bank of the river just downstream from Bridgeport State Park (RM 546).

GLACIOLACUSTRINE MATERIAL BELOW THE OKANOGAN LOBE TILL

The next stratigraphic layer is glaciolacustrine material found below the main till, and presumably laid down in water impounded by the ice. Flint and Irwin (1939) describe a basal sequence below the till at the site of Grand Coulee Dam which is characterized by higher clay content than the bedded sands and silts that overlie the till and by graded beds of sand fining upwards to silt. These beds are called varves in Flint and Irwin's report but could be turbidites. This basal sequence is not seen in the study area except possibly between RM 570 and 567, where till overlies contorted silts and sands at one locality (RM 567.4) and appears to overlie bedded silts at several others. Clay content is not noticeably high at these localities. Elsewhere, bedded silts and sands overlie till. Sediments which underlie the till were deposited in water held in by ice which blocked the canyon but had not yet filled it; sediments overlying till were deposited in water held in by ice left by the wasting Okanogan Lobe.

OKANOGAN LOBE TILL

Below the mouth of the Nespelem River only one till has been recognized. A younger till has been noted upstream from the Nespelem River at elevations ranging from 1,600 ft at a point east of the northern end of Bailey Basin to 1,360 ft at lower Kaiser Canyon (Jones et al. 1961). It is seen nowhere else. The till downstream from the mouth of the Nespelem River is grey, tough and hard, with a platy structure, and contains mostly basalt clasts in the lower canyon along the river and in the canyon walls. In the upper canyon, till is not exposed along the river. Where found along the canyon walls, clasts are mostly derived from the granitic bedrock. In the lower canyon, lithologies found in amounts less than 5% include, in order of decreasing frequency, coarse cherts, metavolcanics, porphyritic acidic volcanics (Pardee's rhyodacite) and nephrite. The limited exposure examined in the upper canyon did not provide enough data for analysis. Flint (1935) notes that volcanics seem to be absent there, reflecting a more limited volcanic outcrop to the north. Between RM 563 and 560, the till along the river is underlain by a deposit containing very few clasts. It was called "Gaviota clay with pebbles" in the U.S. Army Corps of Engineers' map of 1971. This unit records "a different depositional environment from the harsher environment of lodgement till or dump-moraine deposition" (R. Galster, personal communication 1980). The contact with the overlying till is gradational. Both the lower and upper parts of the till will hold a steep bank and a fairly deep undercut, and are easily recognized along the river. The bottom of the till is seldom exposed

Table 2-1. Radiocarbon dates (samples were dated at the Radiocarbon Laboratory, Balcones Research Center, University of Texas, Austin).

Project Sample #	Laboratory Sample #	Radiocarbon Age in Years B.P. T1/2=5,568	Description
6 VIII 9-2a,b	TX-3803	24,820±1760	Carbon-rich clay and silt from foreset openwork gravels underlying till, left bank of Columbia River opposite Brants Landing, RM 553.
30 VIII 9-2	TX-3801	>40,000	Charcoal in clayey silts, 1,350 ft terrace cut, Alameda Flat, left bank of China Creek.
CRP - 1	TX-3802	30,540±3110	Peat from lens in debris-flow/dump-moraine material underlying till, just upstream from boat boom on north bank of Columbia River at Chief Joseph Dam.
CRP - 2	TX-3804	>40,000	Peat from lens next to CRP - 1.
CRP - 3	TX-3805	>40,000	Charcoal from slide below till, south bank of Columbia River across from Chief Joe Orchards, RM 570.7. Approximately 125 cm above talus, east side of exposure.

and the top in most places has been planed off by the river. The till extends up to the canyon rim in Sec. 24, T30N, R26E, and in places on the south wall upstream from Bridgeport.

ICE-CONTACT STRATIFIED DRIFT

The ice and its associated ice-marginal streams created what is known as ice-contact stratified drift. This deposit, formed in ice-marginal streams carrying meltwater from the ice and drainage from lakes in side canyons, is contemporaneous with some part of the Okanogan Lobe till. It is found mostly above 1,800 ft. It comprises poorly sorted, well-rounded sand and gravel in discontinuous beds displaying abundant cut-and-fill features. It is often slumped toward a valley or canyon. Granitic clasts are the most common, in combination with subordinate metasediments (quartzite and minor slate possibly derived from far upriver) and porphyritic volcanics. Little basalt is found except near outliers to the north of the river.

LATER FLOOD DEPOSITS IN THE CANYON

At various times since the retreat of the ice, floods have passed through the canyon. At Allen Bar, RM 561 and 562, the till is overlain by gravels that contain crystalline-bedrock, volcanic, and metasedimentary clasts up to three feet in length, in a sandy matrix. The gravels are foreset 15-20° downstream. Similar gravels in similar foresets are found at Mah-kin Rapids (RM 572.3) on the south bank and on the river's north bank at RM 571 where they are overlain by slump blocks of the Latah Formation which resemble till at first glance. These gravels are of uncertain stratigraphic position but appear to overlie till. All these gravels differ from those underlying till farther down the canyon, in that they have a fine-grained matrix instead of openwork structure. They also contain only small amounts of basalt, display a smaller maximum clast size, and contain no interbed material.

TERRACE SANDS AND SILTS

This fill was deposited in Glacial Lake Columbia during the down-wasting of the Okanogan Lobe. The terraced fill in the upper canyon is mostly well-bedded fine sands and silts, tan when weathered and light grey when fresh. Sand predominates above approximately 1,200 ft; the entire sequence extends from below river level to 1,800 ft. Above that elevation to at least 2,400 ft, well-bedded clays and silts form the fill in many tributary canyons. These higher sediments predate the thicker fill in the main canyon; they formed in lakes impounded by ice which lay in the main canyon. They could not have been deposited when the canyon was free of ice.

The main canyon fill is largely very fine to coarse sand with subordinate silt beds. Lenses and beds of pebble- to boulder-sized gravels are common at the mouths of tributary canyons. Clean exposures are rare. An exception is the cut on the north bank of the river from 1,280 ft down to 1,040 ft along a road in Sec. 6 and 5, T30N, R29E, which displays fine sand in thin (<1 cm) beds with some ripple bedding. This cut is in a terrace that descends in a downstream direction from the mouth of Hopkins Canyon. It is cut out of higher material and capped by a lag-gravel pavement. The bottom of the cut shows imbricate Columbia River gravels dipping away from the river. A similar sand section between the same elevations can be inferred from slope angle and rolldown clasts along the road up the terrace fronts at the mouths of Hopkins Canyon and the Nespelem River.

From the river's edge to 1,320 ft, cutbanks show the following sequence: river to 1,200 ft--laterally extensive, very well-bedded silts and fine sands, capable of holding nearly vertical slopes; above 1,200 ft--similarly bedded, light-tan fine sands, which generally support slopes at the angle of repose. Charcoal from these sands at China Creek, around 1,280 ft, has been dated at older than 40,000 years (TX-3801) but this is probably redeposited material since these beds show no signs of having been overrun by ice even though the late Wisconsin ice limit lies to the south.

From 1,040 ft to 1,120 ft on the south bank of the river upstream from China Creek, horizontal beds of foreset Columbia River gravels rest disconformably on the bedded silts, and are overlain by the bedded sands. Above RM 575, the gravels are lying in a channel cut into the silts. Judging by the top of the deposit which lies at 1,200 ft, approximately 160 ft of it have been removed. These bedded gravels can be seen in cutbanks upstream as far as Nespelem Bar. Farther upstream the record is gone. At a pumping station at Brewster, eight miles downstream from Bridgeport, what appear to be the same gravels within the same sequence are graded upward from cobble to coarse sand, but it is not possible to fit this locality into sedimentation patterns upstream from the Omak Trench. The section exposed along the road in Sec. 6 and 5, T30N, R29E, can be read as the same sequence as that in the cutbanks although the bedded sands are preserved to a higher elevation.

The main canyon fill between 1,400 ft and 1,800 ft is not well exposed. Between 1,600 ft and 1,800 ft in Strahl Canyon, above Alameda Flat, horizontally bedded silts and sands are exposed in a stream cut; the fill has a flat, level surface with no gravel visible on its top. Jones et al. (1961) describe a section in lower Kaiser Canyon (RM 585.4), from 1,500 ft to 1,700 ft, that is also composed largely of bedded sand, and the bank between 1,800 ft and 1,400 ft along the road from the Colville Indian Agency down into the canyon is a sand slope with minor amounts of gravel included. The latter two localities support the idea of a sand fill from river level to 1,800 ft in the canyon.

The main canyon fill is almost lacking in the lower canyon. Slumped sands on the south bank of the Columbia between RM 566 and 567 are probably downstream examples of the main canyon fill. These sands should not be confused with the much coarser sands found below the till between RM 565.5 and 562. Bedded sands similar to the section in the upper canyon are found discontinuously up to 1,600 ft on the south canyon wall upstream from Bridgeport, Sec. 17, 16, 20 and 21, T29N, R26E. What appears to be the same material occurs up to above 1,400 ft on the north canyon wall northwest of Bridgeport State Park.

POST-TERRACE DEPOSITS

Alluvial fans of gravel, sand, and silt are built out onto terrace surfaces at the mouths of tributary canyons. Cuts in fans occasionally reveal layers of pinkish tephra (Mazama Layer O) up to a foot and a half thick, high up within the fan material and conforming to the fan surface profile, indicating that the fan was active when the tephra fell about 6,700 years ago, and that the terrace surfaces on which the fans are built were in existence long before then. A good example of such a fan is cut by the main road at the stream draining Hopkins Canyon, SE 1/4, Sec. 24, T31N, R29E. Fans in the canyon are currently deeply trenched by the streams that built them.

Most surfaces in the canyon that are flat enough to retain it have a cover of brown loess one meter or less thick, probably derived from ice-recessional deposits on the Waterville Plateau to the south and from the canyon itself. Prevailing winds are now from the southwest, and strong winds continue to blow the silt in the canyon about. Active sand dunes are found in the Omak Trench south of Goose Lake and on the 1040 ft terrace above the slump east of the Nespelem Bar.

GENERAL DISTIBUTION OF QUATERNARY DEPOSITS IN THE PROJECT AREA

OKANOGAN LOBE TILL AND PRE-TILL DEPOSITS

Giant gravels and coarse sands and the massive dump moraines or debris flows which overlie these deposits predate the Okanogan Lobe and underlie the till left by it. These pre-till deposits are exposed along the river from about RM 571, just upstream from the mouth of the Omak Trench, to three miles above Chief Joseph Dam. Upstream from RM 571, the till and underlying deposits are concealed under terrace material, excpt where the terraces have slumped or been eroded.

Till, but no underlying material, is found along the walls of the Omak Trench a mile or so north from Goose Lake, where it appears to have been cut into by a wide stream flowing down the Trench, a possible sign of another large flood. Till is also found at the canyon walls in places upstream from the Omak Trench, especially above Alameda Flat and along the Nespelem River south of the town of Nespelem and also where the river descends into the Columbia Canyon. In the northern part of the Little Nespelem's drainage, just east of Highway 155, Okanogan Lobe till is also visible. In the lower canyon, below RM 555, till forms most of the Columbia's banks, and covers the entire northern wall of the canyon on the west side of Tumwater Basin.

Ice-contact stratified drift, associated with the glacier's retreat, has been mainly noted in the upper canyon. A massive deposit lies one-half mile west of the town of Nespelem. Its apparent thickness is 600 ft. Spotty occurrences along the canyon's eastern wall are found for miles south of Nespelem.

MORAINES AND FIELDS OF ERRATICS

Lateral moraines formed by the ice that once filled the portion of the canyon located in the project area are prominent in four places: 1) in Sec. 35, T31N, R30E, just into the canyon from the Nespelem dump; 2) in Sec. 12 and 13, T30N, R30E, just south of where the Little Nespelem River crosses Highway 155; 3) in Sec. 27 and 34, T30N, R31E, west and south of Buffalo Lake; and, 4) in Sec. 3 and 4, T29N, R31E. The moraines near Buffalo Lake mark the edge of the Okanogan Lobe and also an edge of the wasting ice fields in the canyon. The area to the north and east of Buffalo Lake remained unglaciated throughout the later Pleistocene. In general, the edge of the glaciated area is marked by the distribution of erratics rather than by terminal moraines. The edge can be followed at an elevation close to 2,400 ft from Buffalo Lake northward over the divide into the Little Nespelem drainage, and from there along a prominent ice-margin channel in Sec. 15 and 21, T39N, R31E, on across Joe Moses Creek, and into the valley of the Little Nespelem. The margin swings northeast to cross the ridge between the Nespelem and Sanpoil River valleys about three miles north of Cache Creek Road. South of a line from Buffalo Lake to the center of Sec. 29, T31, R31E, the erratics are almost entirely basaltic, indicating that the ice reached outliers of Columbia River Basalt north of the canyon in this area. North of this line, erratics are derived almost entirely from granitic bedrock.

Moraines are not common elsewhere in the study area, but there are some prominent fields of very large basalt erratics sometimes called haystacks. Three of the most prominent fields are: 1) at Belvedere (sec. 36, T30N, R30E) on Highway 155; 2) along the north bank of the Columbia just downstream from the Omak Trench and perhaps looping across the river to the south of Parsons Rapids at RM 564; and, 3) along the east bank of the river at RM 566-568, across from Tumwater Basin. All these fields are in areas where terrace material is thin, as at Belvedere, or entirely absent. There are a few remnants of it just downstream from the Omak Trench but very little downstream from there. Haystacks of similar size are found on bedrock or thin cover in the canyon itself throughout the study area, but not in such noticeable concentrations. Erratics are seldom found on terraces, but are occasionally found at the contact between terrace material and underlying till or bedrock. This relationship supports the hypothesis that the terraces are glaciolacustrine fill since more erratics might be expected on terrace surfaces if they originated at the ice margin.

ICE-ASSOCIATED CHANNELS AND SPILLWAYS

Channels formed by glacial meltwater (ice-marginal channels) often follow a northwest-southeast joint system of bedrock in the Omak Trench. Flint (1935) states that channels in the Trench were cut by ice-marginal streams and also display signs of smoothing and scratching by ice. For this reason, he infers at least two ice advances down the Trench.

Channels cut into the canyon walls by streams flowing along the edge of the wasting ice are not common in the Columbia Canyon itself, but there is a beautiful example of a hanging channel just south of where upper Kaiser Canyon meets Highway 155. The most noticeable channel in the canyon itself rounds the bend where the Columbia turns south directly across from the mouth of the Omak Trench. It cuts at least 30 ft into bedrock above the south bank of the river at an elevation of 1,800 ft. The margin of the wasting ice must have lain here for some time in order to cause such a dramatic channel. The erratic field in the area (the second described in the above section) may record this long stillstand.

The ice in the Columbia Canyon impounded many lakes in tributary canyons above the north bank of the river in the unglaciated region south of the Little Nespelem. As the side canyons filled, water flowed through low points in the interfluves and cut a series of spillways that today are steep-walled canyons in the basalt and the underlying bedrock. Upper Kaiser Canyon is an example. Others are found in Sec. 28 and 35, T30N, R31E, and in Sec. 9 and 10, T29N, R31E. As the canyon ice melted away, lower and lower base levels were established for these tributary lakes, and spillways were cut at successively lower elevations. A similar series of spillways is found above the east shore of Omak Lake. Farther to the north, Omak Creek formerly emptied into the Omak Trench through a 400-ft-deep spillway in Sec. 14, 22, 23, and 27, T33N, R27E. Upper Coyote Creek flows in the spillway where a large lake in the valley east of Omak formerly discharged through Disautel Pass. Hopkins Canyon may represent a similar channel that drained a lake in the valley of Smith and Condon Creeks, or it may be the path of an ice-marginal channel along the east side of the Omak Trench that was forced to flow over the shoulder of Whitmore Mountain when ice filled the Trench at the point where it turns southwest, south of Boot Mountain. Fill at approximately 1,400 ft extending from the main canyon into Hopkins Canyon indicates that Hopkins Canyon was cut before Glacial Lake Columbia filled the Columbia's canyon, either during an ice advance before the last, late Wisconsin one or possibly during the last advance after ice had filled the Omak Trench and so forced meltwater around Whitmore Mountain. This occurred before the main canyon was blocked by ice, impounding Glacial Lake Columbia.

TERRACES

The prominent system of terraces, traceable far upstream past the Grand Coulee, exists only as remnants downstream from the mouth of the Omak Trench. Flint (1935) reported his Nespelem silt terrace at about 1,800 ft along the west wall of the Trench, but limited examination of that area shows only bedrock. There is one terrace remnant at 1,800 ft above the north bank of the Columbia just downstream from the mouth of the Trench. It was probably continuous with the slumped rhythmically bedded sands and silts across the river just upstream from Parsons Rapids (RM 566.5) on the opposite shore of the river. The upper limit of this latter material is not known.

A good example of a terrace above 1,800 ft that is not part of the main canyon system is between 1,800 ft and 2,200 ft above the north bank of the Little Nespelem. It is composed of material deposited in a lake impounded by the ice in the main canyon. The later 1,800 ft terrace can be seen to be set into the higher terrace in this area.

Ice-marginal terraces, the floors of abandoned, perched ice-marginal streams, are composed of ice-contact stratified drift. Their distribution has been described earlier. The terrace surface west of the town of Nespelem, at 2,400 ft, is some 600 ft above the outwash in the valley of the Nespelem River; the outwash overlies the top of 1,800 ft terrace. Since the 1,800 ft terrace postdates the ice-marginal one, it probably buries the lowest part of it, an indication that the 2,400 ft terrace is even thicker than it appears. Other ice-marginal terraces in the study area are much smaller than this one.

The most prominent surfaces developed in the terrace system of the main canyon fill lie at 1,800 ft, 1,400 ft, 1,240 ft, and 1,000 ft. The 1,800 ft level, as stated earlier, is most likely the top of the glaciolacustrine fill in the main canyon. That is, it represents the highest bottom of Glacial Lake Columbia, dammed by ice farther down the canyon. This surface is kettled in Sec. 17, T29N, R31E and Sec. 24, T30N, R30E. Mt. St. Helens Set 'S' tephra, about 13,000 years old, has been reported atop this terrace above Elmer City (Kiver and Stradling 1982). At roughly this same elevation, in both the upper and lower canyon, are doublet features interpreted as strandlines by geologists of the Energy Systems Group of the Rockwell Hanford Operation (L. Hanson, personal communication 1979). These features are clearly visible above the south bank of the Columbia in the NE 1/4 Sec. 20, T30N, R29E at Alameda Flat, and from northeast to southwest across Sec. 10, T29N, R26E, seven miles east of Bridgeport. A possible strandline also appears west of Hopkins Canyon on the face of Whitmore Mountain. An ice-dammed lake occupying the canyon and having a shoreline near 1,800 ft could account for the deposition of the material in the main system of terraces. We do not know whether the doublets in the upper and lower canyons are at the same elevations.

The 1,400 ft level is strongly expressed on the north bank of the river from Buckley Bar down past the mouth of the Nespelem River, and again at the mouth of Hopkins Canyon. It is present at Alameda Flat above the south bank, where it has been modified by erosion and subsidence, but absent in the lower canyon except for a possible remnant in Sec. 11 and 12, T29N, R25E, near Bridgeport State Park. Where the 1,400 ft terrace can be examined, the surface, which I believe to be a stream-cut surface, has a layer of Columbia River gravels of mixed lithologies beneath the usual loess. Jones et al. (1961) map till at this elevation in lower Kaiser Canyon, and account for it by postulating a readvance of the Okanogan Lobe; this till, however, is found nowhere else, and it may represent only a marginal fluctuation that occurred prior to the deposition of the main canyon fill.

The 1,240 ft surface is found in the upper canyon and in the Omak Trench south of Omak Lake. From Omak Lake north, the surface is not found. This surface level remains enigmatic: in none of its exposures has a capping layer of Columbia River gravel been found. In the Omak Trench south of Goose Lake, the surface extends into the channel occupied by Goose Lake, indicating that a channel was cut through the Trench before the formation of the 1,240 ft level. This relationship and the lack of a gravel surface layer suggest that the 1,240 ft level is a depositional surface. If so, it must postdate the 1,800 ft fill.

The lowest strongly expressed surface in the canyon lies at about 1100 ft near Grand Coulee Dam. It descends downriver to 1000 ft at the mouth of the Omak Trench and below that at Allen Bar and Gaviota Bend. It is not well expressed farther down the canyon. The surface is often covered with Columbia River gravel, overlain by loess or alluvial fans. The gravel cover is more than 15 ft thick in places.

The next lower surface was mostly submerged by the pool behind Chief Joseph Dam, but fans built onto it remain partly above water and form the substrate for many of the sites under investigation by the Chief Joseph Dam Cultural Resources Project.

OUTWASH FEATURES

Glacial outwash is not common in the canyon. Above Parsons Rapids, the main canyon glaciolacustrine fill conceals most low areas where outwash might have been preserved. In the lower canyon, not much is left but till, flood gravels, and bedrock. A portion of an outwash sequence may be preserved on the north bank of the river opposite Lone Pine Island, near RM 560.7. Here, poorly sorted sands and gravels of mixed lithologies overlie till. Bedding is discontinuous, strongly suggesting a cut-and-fill pattern. The section is truncated by a stream-cut surface at about 940 ft. This material may be ice-contact stratified drift, instead of outwash.

In the Omak Trench a flat surface between 1,320 ft and 1,360 ft on either side of Goose Lake may be an outwash surface. A gravel pit next to the highest portion of the road east of Goose Lake shows that part of the surface is underlain by river gravels foreset to the south. Paired terraces underlain by till occur at the south foot of Boot Mountain and across the Trench at the foot of Whitmore Mountain. These may record a stillstand whose outwash plain is the 1,320 ft-1,360 ft surface.

Outside the canyon proper, a fine three-stage outwash sequence is recorded south of Owhi Lake. An early drainage, probably from ice in what is now Owhi Flat and Owhi Lake, left an outwash plain above 2,640 ft in Sec. 15, 22, and 23, T31N, R31E. Later drainage from the ice that lay to the west in the canyon of the Nespelem cut across and into this plain, and drained into the Little Nespelem, which had to cut across the earlier outwash plain, in Sec. 26, to flow to the main canyon. Currently, Cache Creek road follows this cut in Sec. 15 and 22. Sections 14, 13, and 24 contain white clays laid down in a lake impounded by the early outwash plain, which extended across the valley of the Little Nespelem and blocked the river.

FLOOD FEATURES IN THE OMAK TRENCH

Aerial photos of the Omak Trench south of Omak Lake show scarps cut into till on both sides of the Trench. Just north of Goose Lake is what may be a channel bar more than a mile long; and, what is perhaps a giant ripple field similar to the giant subaqueous ripples associated with Missoula flooding appears one-half mile northwest of Goose Lake. Ground examination of the bar-like feature at the ripple field's edge revealed a field of rocks averaging more than a foot in intermediate diameter. This field resembles the boulder-covered bars along the Columbia below Lake Chelan that have been interpreted as deposits of very large floods; it may be the bedload of a large flood down the Trench. Large foreset openwork gravels, containing clasts up to a foot in intermediate diameter, are found just to the north of St. Mary's Mission at the north end of the Trench.

DEPOSITS POSTDATING OKANOGAN LOBE TILL

The flood gravel which overlies the till is known with certainty only at RM 561. What are probably the same gravels are exposed between RM 570 and 571. The main canyon fill extends upstream from RM 565, a point about a mile downstream from the mouth of the Omak Trench. Downstream from there, the terrace system and its associated material are not common. The floor material of the Omak Trench is the same sand that makes up the main canyon fill at the point where the Trench joins the Columbia River Canyon.

SLUMPS

Flint and Irwin (1939) noted that the entire Quaternary section of deposits at the Grand Coulee Dam site was broken by slumping. Massive slumps are found for several miles downstream from the dam, especially on the north bank, and continue to be common into the study area. Bailey Basin is an easily seen slump scar south of the mouth of the Nespelem River, and the entire bank has slid in the stretch from there to north of the mouth of the Nespelem. The fill is also displaced between RM 578 and 579, as is the south bank at RM 580, the north end of Bissell Flat. Parsons Rapids marks another large slump, a quarter of a mile long; the Bridgeport slide, on the south bank upstream from Chief Joseph Dam, is larger. The latter involves till and other sediments and bedrock while those upstream are all in the main canyon fill. Pool raises in Rufus Woods Reservoir may initiate new bank failures in the main canyon fill.

CENOZOIC HISTORY OF THE REGION

The outpouring of the Columbia River Basalts in the Miocene pushed the Columbia River west of its original course, into a new channel along the north and west of the basalt plateau where it may have met the Okanogan River at Omak. In a few places, such as north of Grand Coulee Dam, the river exploited weaknesses in the basalt and cut off outliers, but the plateau-marginal pattern may have held until sometime in the Pleistocene. At that time, an ice sheet moving from the north pushed the river west from Whitmore Mountain and held it there while it cut what we know today as the lower canyon into the Plateau basalts. When this happened, and how many times, is not known since the maximum advance of the Okanogan Lobe of the Cordilleran Ice Sheet destroyed or covered evidence of earlier ice advances. But it is certain the Columbia River from the upper Grand Coulee downstream to far beyond Bridgeport was covered by the Okanogan Lobe of the Cordilleran Ice sheet at least once during late-Pielstocene time. The Okanogan Lobe is thought to have reached its maximum extent during the mid-Pinedale advance (Richmond et al. 1965), at which time it built a large terminal moraine (the Withrow moraine) some 35 miles south of the canyon. Waitt (1972) has shown that the Okanogan Lobe and the Puget Lobe merged across the North Cascades, and Hibbert (1979) has shown that the Puget Lobe reached its maximum extension between 13,000 and 14,500 B.P. The Okanogan Lobe may have reached its maximum extension about the same time. Dates from a peaty deposit beneath the till at Bridgeport State Park are 30,540±3110 B.P. (TX-3802) and more than 40,000 B.P. (TX-3804) and carbon-rich clay and silt from below the till on the south bank of the river at RM 553 yielded a date of 24,820±1760 years B.P. (TX-3803), indicating that the Okanogan Lobe reached the lower canyon no earlier than about 25,000 years ago.

Aerial photos of the region show that the ice flow during the last advance across the canyon was roughly north-south in orientation, heading downstream from the Omak Trench. A part of the lobe, somewhat to the east, pushed farther up the Columbia until the ice was moving almost due east at the upper end of the Grand Coulee.

In his study of regional glacial activity, Baker (1978) describes a possible scenario for the vast outburst flooding that took place during the late Pleistocene when the ice sheet still extended into the area. An enormous lake known as Glacial Lake Missoula was impounded in western Montana when the Pend Oreille Lobe of the Cordilleran Ice Sheet blocked the Clark Fork River. Several times (recent estimates vary from twelve to forty) during the late Pleistocene, the ice dam gave way and gigantic floods swept down the Spokane and Columbia Rivers. Those floods cut the channeled scablands of eastern Washington in all the areas where the ice filling the canyon of lower Columbia blocked their passage. Flood waters flowing around the nose of the Okanogan Lobe formed Moses Coulee (Hanson 1970) and a later flood which occurred when the ice lay farther south formed Grand Coulee. Missoula outbursts that occurred when the canyon was not occupied by the Okanogan Lobe flowed through the canyon and on down the Columbia channel past present-day Lake Chelan and Wenatchee where huge point bars remain as record of the flooding.

Giant gravels which lie below Okanogan Lobe till in the lower canyon testify to floods before the Okanogan Lobe last filled the canyon. Ripup clasts of bedded sands and silts contained in these gravels may record a lake dammed by an earlier advance into the canyon. This lake may have sapped and undercut the walls of the canyon, causing their collapse. This, in turn, brought great masses of rim basalt down into the canyon, carrying deposits from the plateau surface with them, including the peats found in what may then be large debris flows overlying the gravel deposits. Some of this peat (see above) is radiocarbon dated to 30,540±3110 B.P. (TX-3802). This date may indicate the age of the flood, but the flood could be later.

After its maximum advance, the ice of the Okanogan Lobe wasted down in place with much of the meltwater flowing out along the ice in the canyon. The strandline doublets and the bedded sands of remarkably uniform appearance, found throughout the canyon from Chief Joseph Dam upstream to beyond the Grand Coulee, suggest an ice dam in the vicinity of Bridgeport. There is no field of erratics to mark the site.

As the Okanogan Lobe wasted down in the canyon, the level of Glacial Lake Columbia, impounded by ice, dropped. That the ice sheet wasted in place, rather than melting back to the north, is shown by widespread dead-ice terrain and ground-moraine on the Waterville Plateau. As the ice surface dropped in the canyon, lateral moraines and ice-marginal stream beds were stranded and the spillways for side-canyon lakes cut deeper and deeper, and new ones were formed at lower elevations. The surface of Glacial Lake Columbia seems to have been near 1,800 ft twice to account for the strandline doublet in the upper canyon. Kiver and Stradling (1982) report the presence of Mt. St. Helens Set 'S' tephra on the 1,800 ft terrace above Elmer City, showing that sediment had been deposited at that elevation more than 13,000 years ago. The doublet in the lower canyon northeast of Chief Joseph Dam appears to be at a lower elevation, but accurate leveling has not been carried out. It is unclear at what stage in the history of the lake the strandlines formed, and whether they all record the same lake levels or even the same lake. If they do, they could provide information on amounts of postglacial isostatic rebound throughout the canyon.

As long as the lake level was held above the elevation of the intake to Grand Coulee (now at 1,550 ft to 1,600 ft), the lake drained out primarily through the Coulee, but after the wasting ice in the canyon allowed the lake level to drop below that level, the river had to flow out through the lower canyon or through the Omak Trench. The lack of lake fill higher than about 1,360 ft in the Omak Trench suggests that the Trench was blocked by ice which kept out Glacial Lake Columbia until sometime after the lake level dropped below the inlet to Grand Coulee. This would mean that the Columbia must have been flowing out through the lower canyon instead of through the Omak Trench.

The material deposited in Glacial Lake Columbia was dissected by the Columbia as the downstream ice dam wasted away and was cut into by the river. The river was held near an elevation of 1,400 ft before it resumed downcutting. Ice melting back in the Omak Trench when the river was near the 1,400 ft elevation built an outwash plain across the Trench at the present location of Goose Lake, where it met the waters of Glacial Lake Columbia three miles north of the present river. From that time on, the river continued to cut down to an undetermined depth perhaps not too different from that of the present (1979) channel.

After the remaining ice melted out of the Omak Trench, a large flood of unknown depth came down the Trench from the north, leaving foreset openwork gravels near St. Mary's Mission and perhaps building a large pendant bar to the north of Goose Lake. This flood cut a channel in the lower Trench to below 1,200 ft; Goose Lake lies in this channel. We can presume therefore that the Columbia was flowing at some elevation below 1,200 ft from there to its junction with the Okanogan near Brewster. Most of the ice in the Okanogan River and the Columbia must have been gone for the rivers to flow at this elevation. If the ice was that low in the valley of the Okanogan, it is unlikely that enough water was dammed in the valley of Omak Creek to have caused a large flood. The water probably came down the Okanogan, where a patch of what may be giant ripples on the Great Terrace north of Omak may record the event.

The mouth of the channel cut in the Omak Trench by the flood is now filled with the bedded sands that underlie the 1,240 ft surface in the upper canyon. These may have been laid down by a second lake in the canyon. The surface of this lake probably lay not too far above 1,280 ft. The lack of bedded sands in the lower canyon at elevations below 1,240 ft may indicate that it was confined to the upper canyon, perhaps held in by a massive slide from the canyon rim opposite Parsons Rapids, where the basalt rests on weak Latah. The basalt blocks at that locality would then be slump debris rather than glacial. The erratic field does not look like a slide, but the smaller material may have been removed by the last major flood down the canyon from the east. The stratigraphic position of this flood's deposits, and therefore the age of this flood, are uncertain. Its effects are not visible at elevations much above 1,100 ft, and it is difficult to determine whether its gravels underlie the 1,240 ft fill or are set into it. Possibly the second lake in the canyon was held in by a dam downstream from Parsons Rapids.

As the ice barrier continued to melt out, the Columbia finally breached it and returned to its channel in the lower canyon. Fans containing Layer 0 Mt. Mazama tephra (about 6,700 B.P.) are built onto the 1,000 ft surface, showing that the Columbia had completed its dissection of the lake fill well before 7,000 years ago. Since that time, these fans have been cut into by their streams. A pollen diagram from Goose Lake (Dalan, this volume; Nickmann and Leopold, this volume) shows pine pollen increasing in relative abundance in the sediments above the tephra, as grass pollen and sagebrush decrease. The greatest change is at a level halfway between the tephra layer and the top of the sediments. Unsupported interpolation would suggest a date between 2000 and 4000 years ago for this increase in forest cover on the canyon rim. This same time span includes the onset of relatively cooler and wetter conditions over much of the northern hemisphere. Since, according to the diagram, the pines had been in the region for quite some time, the change in the pollen curves probably reflects change in abundance of pine and not its immigration into the area. Changes in the pattern of precipitation in the area (not necessarily in the amount) could lead to more permanent stream flow and to increased forest cover, slowing runoff and thereby reducing the number of flash floods that build fans. Increased precipitation might produce the same result. An effectively wetter climate with increased vegetation cover increases chemical weathering in relationship to mechanical weathering, and so helps reduce sediment in streams, sometimes making them more effective eroding agents. Such regional changes in climate during the past 3,000 years or so have put the final touches on today's landscape.

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3. POLLEN ANALYSIS OF A CORE FROM GOOSE LAKE, OKANOGAN COUNTY, WASHINGTON

by Rinita Dalan

Pollen analysis is a widely used method for reconstructing vegetation and climate. This chapter presents the results of palynological analysis of a core from Goose Lake, Okanogan County, Washington, part of a fossil pollen study aimed at providing paleoenvironmental information for the Chief Joseph Cultural Resources Project. Although pollen analysis had been conducted at several locales in eastern Washington when this study was planned in 1978, the available studies were limited in their applicability to the project's goals because of their methodology or location. Hansen, the pioneering researcher, often lumped nonarboreal taxa into a single group and did not have access to radiocarbon dates (Hansen 1943, 1944, 1947). Later studies by Davis et al. (1977), Mack et al. (1976, 1978b), and Nickmann (1979) were conducted on cores from lakes located some distance from the project area. Therefore we sought to obtain a pollen profile from a lake in or near the project area.

Cores were first collected from Rex Grange Lake (NE 1/4 sec. 36, T. 30 N., R 29E., elev. 770 m), Douglas County, and Seatons Grove Lake (SW 1/4 sec. 36, T 29N., R. 31E., elev. 329 m), Okanogan County, Washington. Based on comparisons with other pollen diagrams from eastern Washington, the Rex Grange Lake core was found to provide only a record of the late Holocene (Appendix C). The Seatons Grove core yielded samples of low pollen content and poor pollen preservation. A core representing a relatively long sequence was then obtained from Goose Lake, Okanogan County, Washington. Analysis of this core is presented below.

SITE SETTING

Goose Lake, Okanogan County, Washington is located within Sec. 19, 20, and 29, T. 31N., R 28E. of the Boot Mountain Quadrangle U.S. Geological Survey. The lake lies at an elevation of 373 m (1,225 ft), approximately 27 km (17 mi) west from Nespelem and 27 km southeast from the city of Okanogan (Figure 3-1). The lake is 733,731 square meters (181.3 acres) in area (Figure 3-2) and has a maximum depth of 3.05 m (10 ft). Goose Lake drains into the Columbia River (Wolcott 1973:308-9).

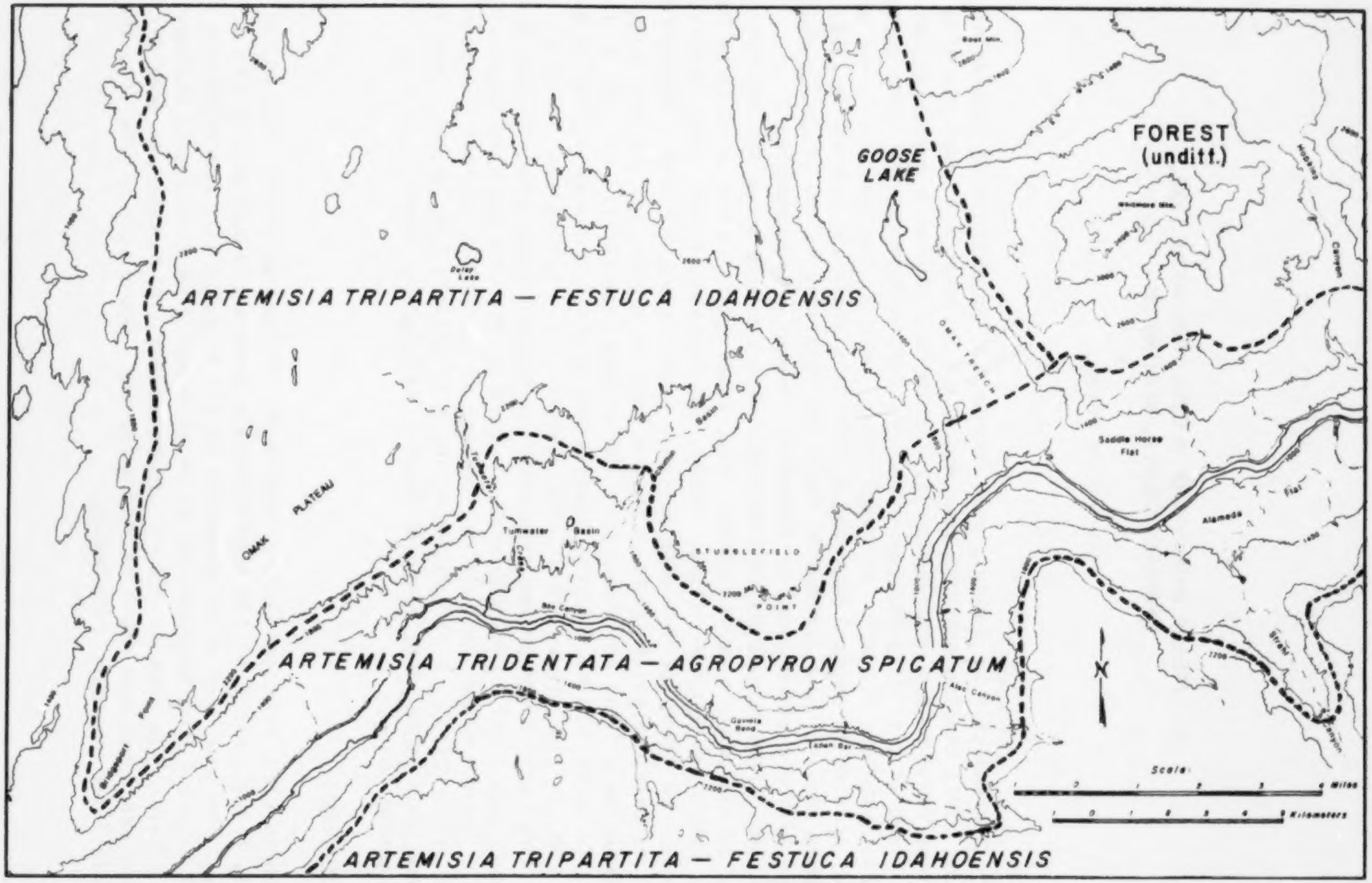
FOREST
(unditt.)
GOOSE
LAKE
Goat Mtn.
Whitmore Mtn.
Hopkins Canyon
OMAK TRENCH
Saddle Horse Flat
Alameda Flat
ARTEMISIA TRIPARTITA — FESTUCA IDAHOENSIS
Daisy Lake
OMAK PLATEAU
Tumwater Basin
Creek
Basin
STUBBLEFIELD POINT
Box Canyon
ARTEMISIA TRIDENTATA — AGROPYRON SPICATUM
Alec Canyon
Coulee Bend
Allen Bar
Strahl Canyon
Bridgeport Bend
N
ARTEMISIA TRIPARTITA — FESTUCA IDAHOENSIS
Scale:
0 1 2 3 4 Miles
0 1 2 3 4 5 Kilometers
1000
1400
1800
2200
2600

Figure 3-1. Location of Goose Lake and relation to modern vegetation zones. Zone boundaries (dashed lines) not accurately to scale because adapted from a larger scale map (Mack et al. 1979:Figure 1, in turn adapted from Daubenmire 1970:Figure 1). Also, at this larger scale the boundaries would be more complex.

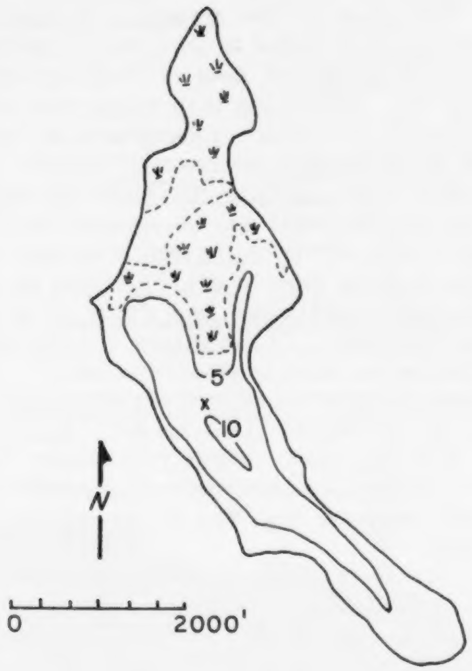

Figure 3-2. Map of Goose Lake showing depth contours in feet (adapted from Wolcott 1973). X marks the core location.

GEOLOGIC HISTORY

Goose Lake lies near the southern end of the Omak Lake Trench (Figure 3-1), an abandoned river channel which extends from the Columbia River near Goose Lake to the Okanogan River near Omak along the north-eastern edge of the Okanogan Plateau (Flint 1935:175-6). During the late Pleistocene, the Omak Trench was covered by the Okanogan Lobe of the Cordilleran Ice Sheet. At its maximum, the lobe extended onto the Columbia Plateau (Richmond et al. 1965:235), terminating 48 km (30 mi) south of Bridgeport. Its southern limit is defined by the Withrow Moraine (McKee 1972:281). The Omak Lake Trench was deepened and enlarged during glaciation (Pardee 1918:47).

MODERN VEGETATION AND CLIMATE

Goose Lake lies only 1.5 km from the forest edge in the steppe region of the Cascade Range rain shadow. Today this region is dominated by bunchgrass and sagebrush steppe communities with forest vegetation generally confined to mountain slopes with sufficient precipitation (Franklin and Dyrness 1973:209).

Nine zonal associations have been recognized in this steppe region. Goose Lake lies on the border of the Artemisia tridentata-Agropyron and the Artemisia tripartita-Festuca zones (Figure 3-1). Undisturbed vegetation in the Artemisia tridentata-Agropyron zone is distinguished by Artemisia tridentata ssp. tridentata (big sagebrush) as the principal shrub, and by Agropyron spicatum (bluebunch wheatgrass) as the principal grass. Variable amounts of Stipa comata (needle-and-thread), S. thurberiana (Thurber's needlegrass), Poa cusickii (Cusick's bunchgrass) or Sitanion hystrix (bottlebrush squirreltail) may be present, but even collectively their coverage never equals that of the Agropyron (Daubenmire 1970:8). The Artemisia tripartita-Festuca zone is distinguished by Artemisia tripartita (threetip sagebrush) and a continuous herb layer of which Festuca idahoensis (blue bunchgrass) is a member. If Artemisia tridentata is present, it is confined to disturbed areas (Daubenmire 1970:28).

The shrub-steppe vegetation of the region surrounding Goose Lake grades into a Pinus ponderosa (ponderosa pine) forest. Pinus ponderosa is able to occupy dryer sites than any other forest type except for Juniperus occidentalis. At higher elevations, the Pinus forest grades into forests of Pseudotsuga menziesii (Douglas fir) and Abies grandis (grand fir) (Franklin and Dyrness 1973:168).

The climate of the steppe region is arid to semiarid with low precipitation. Winters are relatively cold while summers are warm to hot and dry (Franklin and Dyrness 1973:209). In an area including Chelan, Douglas, and Okanogan counties, daily temperature ranges apprximately 7.2°C in the winter and near 16.6°C in the summer. Frequent weather changes occur in the winter when Pacific weather systems occasionally are replaced by arctic air masses. Two thirds of the annual precipitation falls between October and March with most precipitation between mid-December and mid-February falling as snow. The growing season in the three-county area generally ranges from 120 to 180 days. The longest growing season occurs in the Chelan area where it reaches 200 days. On higher, exposed areas, it may drop to 100 days or less. The date of the last freezing temperature varies from mid-March to mid-April in the warmer sections. The first freezing temperatures usually occur in October (Donaldson and Ruscha 1975). Climatic data for selected weather stations in the area near Goose Lake is given in Table 3-1.

METHODS

The Goose Lake core was recovered on February 3, 1979 using a 5-cm-diameter modified Livingston sampler. The core was taken from the surface of 15 cm of ice, near the center of the lake (Figure 3-2). A total of 6.5 m of sediment was recovered. The coring thrust column on the pollen diagram (Figure 3-3) shows the number of thrusts and their depths with the blank area between thrust A and thrust B depicting an area where no sediment was recovered due to mechanical difficulties. Core sections were extruded in the field and wrapped in plastic wrap and aluminum foil for transportation back to the laboratory.

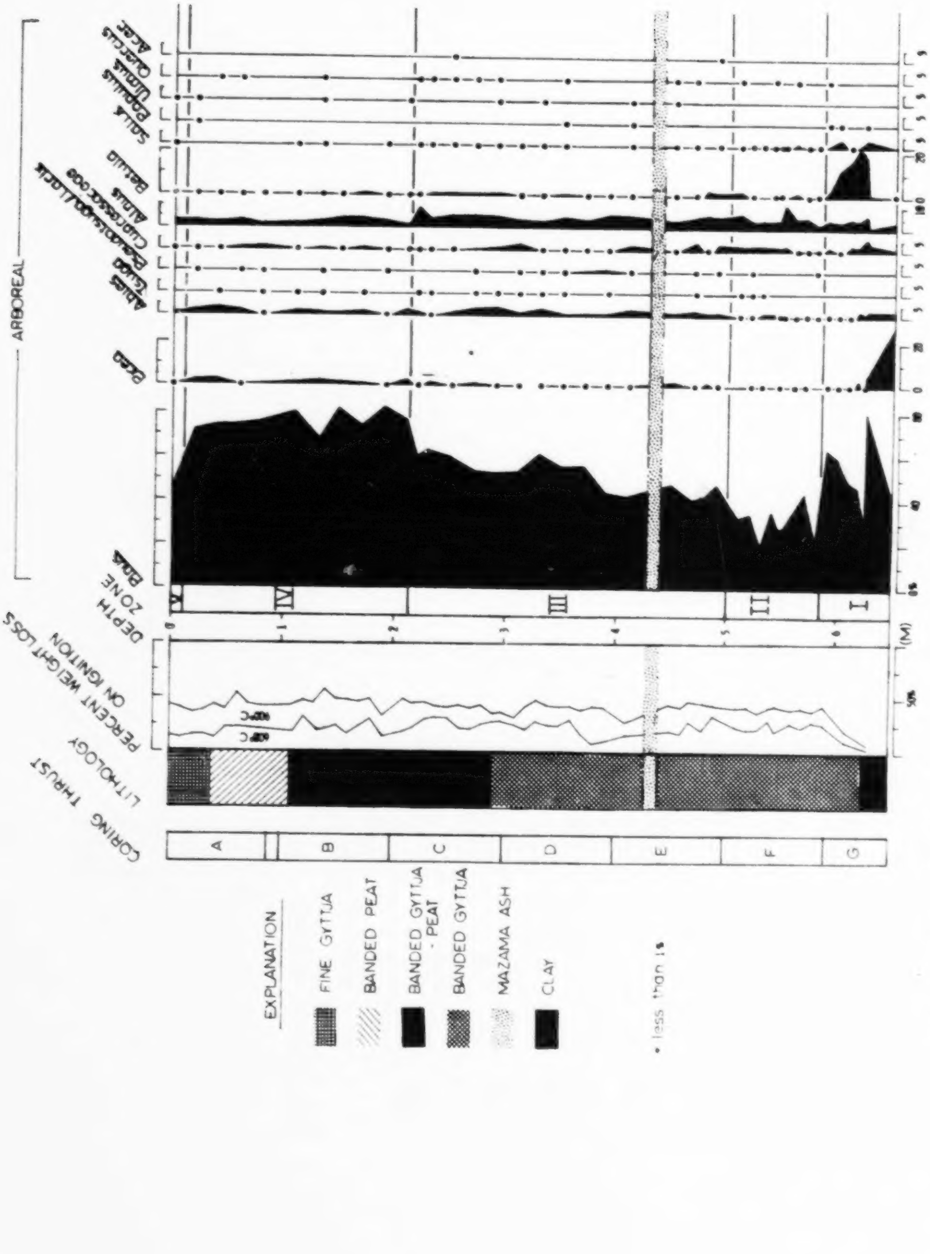

Figure 3-3. Pollen diagram from Goose Lake, Okanogan County, Washington.

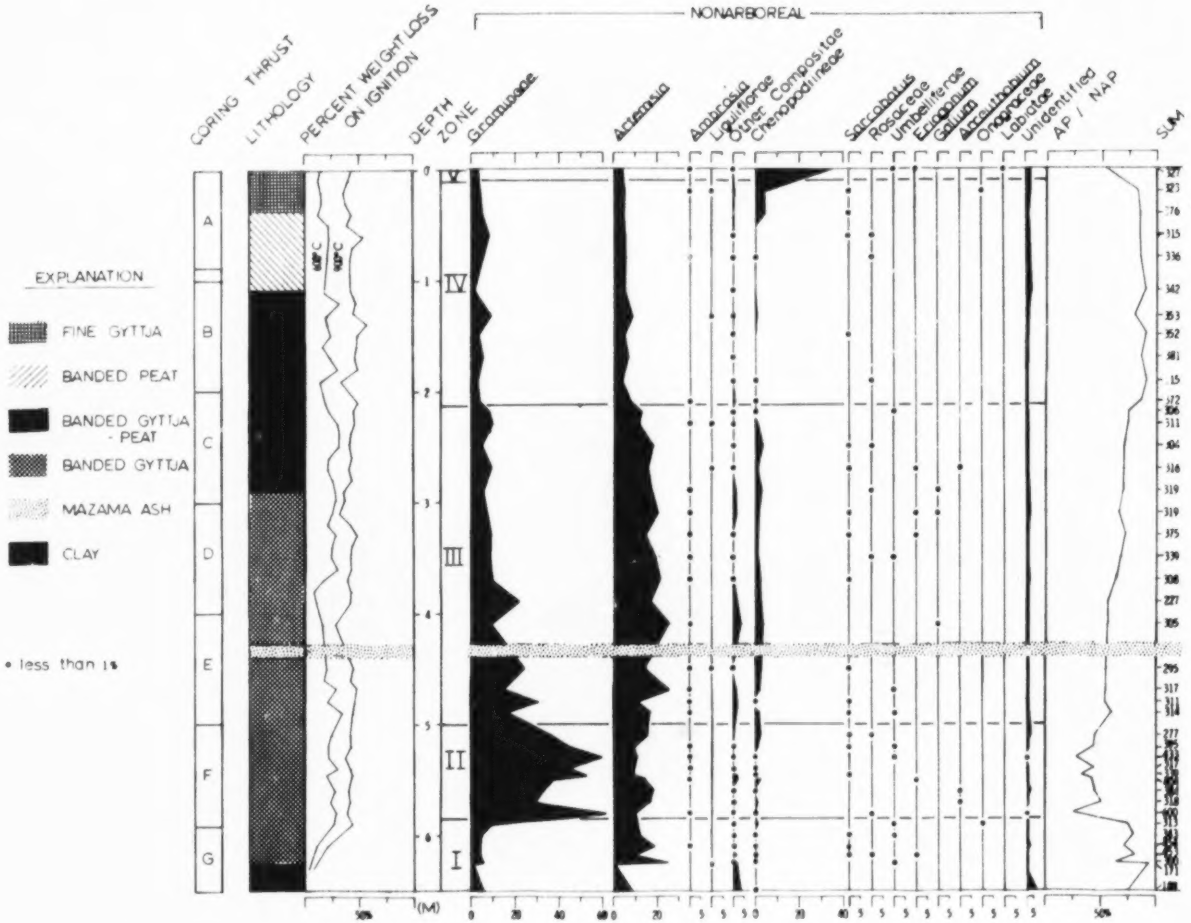

Figure 3-3. cont'd.

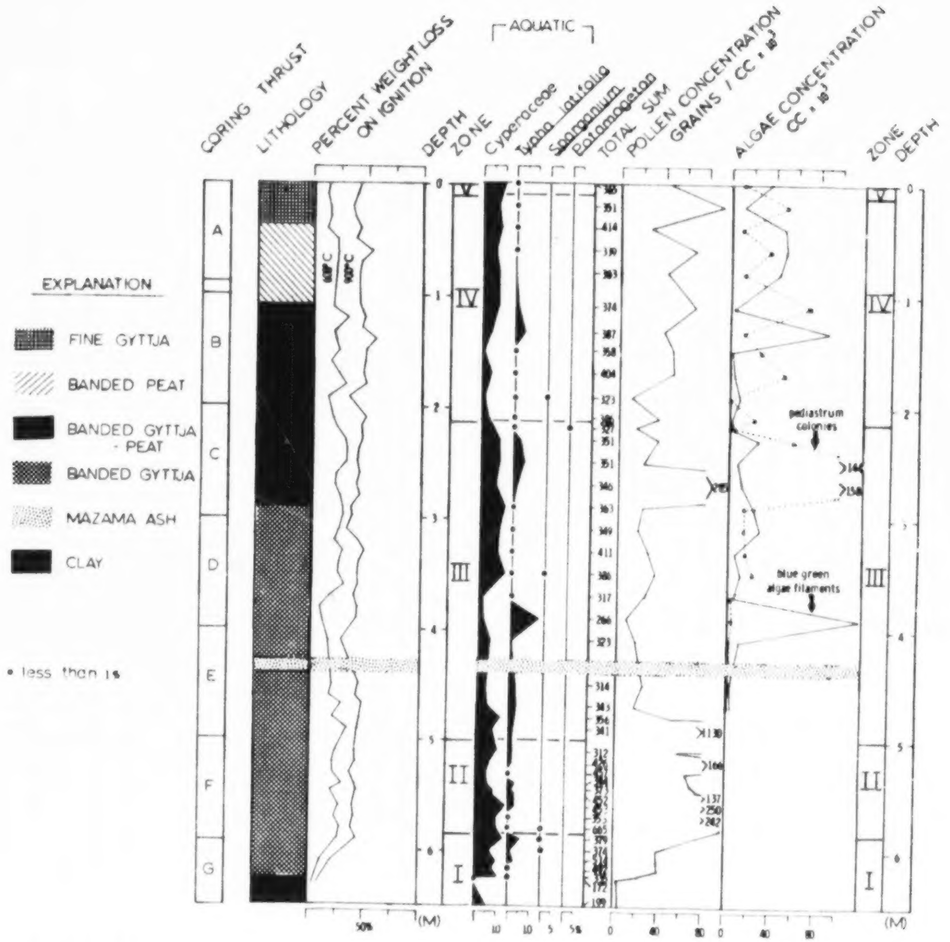

Figure 3-3, cont'd.

Table 3-1. Climatic data from selected weather stations near Goose lake (data from Donaldson and Ruscha 1975).

Station	Nespelem (2s)	Chief Joseph Dam	Okanogan
Location			
County	Okanogan	Douglas	Okanogan
Elevation (m)	576	246	274
Latitude/Longitude	48°08'/118°59'	48°00'/119°30'	48°22'/119°35'
Distance from Goose Lake (km)	28	22	28
Temperature °C			
Average Maximum Annual	16	16	17
Average Minimum Annual	1	3	3
Mean Annual	9	10	11
Low-Mean/Month	-4/Jan.	-4/Jan.	-4/Jan.
High-Mean/Month	21/July	23/July	24/July
Precipitation (cm)			
Mean Annual	33.02	24.68	29.59
Low-Mean/Month	1.21/Aug.	0.45/July	0.66/Aug.
High-Mean/Month	4.01/Jan.	3.86/Jan.	4.59/Dec.

In the laboratory, each coring thrust was cut into 35 cm sections. X-rays were taken of these sections using Kodak Industrex Film. The core was then sliced in half longitudinally and the lithology of the core was described. One half of the core was sampled for pollen and sediment analyses. Two 0.5 cc samples for use in pollen analysis were taken at 10 cm intervals. An additional 0.5 cc sample was taken at each level for weight loss on ignition determinations. Wet mounts were made at each of the major sedimentary changes to help in determining sediment types. To check for the presence of macrofossils, 2.5 cm sections were removed from the core at 20 to 30 cm intervals.

To each of the samples processed for pollen analysis, a known quantity of Eucalyptus pollen in tablet form was added. The samples were processed using standard preparation techniques described by Faegri and Iverson (1975). Because the samples generally had high clay contents, they were further treated according to techniques suggested by Bates (1978) and Cwynar (1979). The pollen residues were mounted in silicone oil and identifications were made at 400X. An attempt was made to count a minimum of 300 terrestrial pollen grains at each sampling interval with the entire slide being counted along evenly spaced transects. A total of 42 levels was counted. Samples in the lower part of the core between 650 cm and 480 cm were counted by R. Nickmann and samples above and including 468 cm were counted by the author.

Percentages of organic and carbonate content were measured by igniting dried samples at 600°C and 900°C for 2 hours.

Results of the analysis are presented in the pollen diagram (Figure 3-3). Percentages of each arboreal and nonarboreal taxon are calculated as percentages of the terrestrial pollen sum (labeled "SUM" on the pollen diagram), while percentages of aquatic taxa are calculated as percentages of the total pollen sum (labeled "TOTAL SUM" on the pollen diagram). This division is an attempt to separate pollen of regional significance from that which is influenced by the local hydrology and vegetation history of the lake. Pollen concentrations (grains/cc) were calculated as follows (Bonny 1972):

$$2 \times \frac{(182{,}000 \times \text{wt. of Eucalyptus spike} \times \text{no. of pollen grains})}{\text{no. of Eucalyptus grains}}$$

Algae concentrations were computed in the same manner substituting the number of pediastrum colonies or the number of blue-green algae filaments for the number of pollen grains. Algae concentrations were calculated only for samples at and above 468 cm.

LITHOLOGY

The Goose Lake sediments are characterized by numerous laminae, ranging in thickness from 0.5 cm to 25 cm. Presumably, these banded sediments are the result of fluctuations in the level of the lake. The lithologic divisions are summarized in Table 3-2.

Table 3-2. Lithology of the Goose Lake core.

Depth (cm)	Description
0-37	Fine brown gyttja
37-109	Numerous colored bands of peat
109-289	Alternating bands of gyttja and peat
289-428	Numerous colored bands of gyttja
428-440	Mazama tephra
440-625	Numerous colored bands of gyttja
625-650	Medium grey clay

Organic and carbonate determinations, although showing some minor fluctuations, remain relatively constant throughout the core. Both organic and carbonate percentages decrease rather sharply in the grey clay.

Numerous small mollusks, including Pisidium cf. P. contortum Prime, Gyraulis cf G. vermicularis, and Stagnicola palustris Muller (identified by Dr. V. S. Mallory, University of Washington) were found throughout the core. These are cosmopolitan species that are common in lakes of temperate regions. Fragments of Chara, an algae which secretes calcium carbonate, are also abundant in the core.

RESULTS AND DISCUSSION

The pollen diagram was zoned according to major changes in pollen percentages. Zone I represents the early postglacial record and is distinguished by erratic but generally high percentages of Pinus (pine) and a Picea (spruce) peak followed by a Betula (birch) peak. Zones II through IV represent the Holocene record. A prominent Gramineae (grass) peak and comparatively low Pinus percentages characterize Zone II. Zone III records an increase in Pinus and relatively high percentages of Gramineae, Artemisia (sagebrush), and Chenopodiineae (goosefoot family). In Zone IV, Pinus continues to increase while Artemisia and Gramineae decrease. Zone V, representing the settlement period, is distinguished by a rise in Chenopodiineae.

Zone I (650-585 cm)

High but variable percentages of Pinus (30-80%), a Picea peak (27%) at 650 cm and a Betula peak (23%) at 617 cm characterize Zone I. Of the other arboreal taxa, there are also significant amount of Abies (fir), Cupressaceae (cypress family), Alnus (alder), Salix (willow), and Populus (aspen). Gramineae percentages are relatively low (under 10%) and Artemisia percentages are variable (1-25%). The arboreal species predominate, but percentages are quite erratic (65-93%). The percentages of aquatic species are low at the bottom of the core but Cyperaceae (sedge), Typha latifolia (cattail), and Potamogeton (pondweed) are all represented by the top of the zone. Pollen concentrations are quite low at 650 cm (5,000 grains/cc) but increase through the zone (to 40,000 grains/cc). The sediments at the bottom of Zone I consist of a grey clay which changes abruptly to a banded gyttja towards the top half of the zone. Organic and carbonate percentages are relatively low in the clay (4.6% organic, 4.0% carbonate, and 91.4% inorganic) but increase in the banded gyttja (26.4% organic, 16.3% carbonate, and 57.3% inorganic).

The grey clay in the bottom half of Zone I probably was deposited during the retreat of the Okanogan Lobe of the Cordilleran Ice Sheet. Glacier Peak ash was not found in the core indicating that either the ice did not retreat from Goose Lake until after 12,000 B.P., or that the ash was scoured from the lake basin by meltwater following the retreat. The low pollen concentration at the bottom of Zone I could either have been caused by a very high sedimentation rate or by a lack of vegetation in the Goose Lake area. Because *Pinus* and *Picea* (both of which are wind pollinated) dominate this portion of the core, they are interpreted as deriving mainly from long distance transport. The change in sediment to a banded gyttja with a high organic content, the increase of many terrestrial and aquatic taxa, and an increased pollen concentration indicate the establishment of vegetation in the area surrounding the lake. *Alnus*, *Betula*, *Salix*, and *Populus* indicate relatively moist local conditions. The presence of Gramineae and the increase of *Artemisia* indicate that open areas comprised an important part of the vegetation. An open woodland comprised of various conifer and other arboreal taxa with open areas of *Artemisia* and Gramineae is inferred. No close modern analogs were found for this zone.

Zone II (585-500 cm)

A spectacular increase in Gramineae (up to 60%) in together with comparatively low *Pinus* percentages (22-43%) distinguish pollen Zone II. Other significant arboreal taxa include Cupressaceae and *Alnus*. *Artemisia* percentages though variable remain essentially the same as Zone I (9-18%). The percentage of aboreal taxa declines sharply in this zone (26-50%). Pollen concentrations increase sharply (up to 250,000 grains/cc). Cyperaceae and *Typha latifolia* are the most important aquatic taxa. The sediment consists of a banded gyttja with essentially constant organic and carbonate content.

The sudden increase in Gramineae and relatively high *Artemisia* percentages indicate a dramatic shift towards a more open vegetation. A grass-steppe vegetation is inferred from the pollen percentages. Low *Pinus* values suggest that *Pinus* forests were not located near Goose Lake. Nickmann (1979) interprets a similar zone (Zone II) at Williams Lake Fen, Spokane County, Washington as representing a grass-steppe type of vegetation. The radiocarbon date for his Gramineae peak is 9,520 ±400 years B.P. A grass-steppe interpretation also is supported by the resemblance of the pollen percentages of Zone II to the modern pollen rain of the mixed grass prarie in the Powder River Basin and on the South Dakota Plains (McAndrews 1969).

Zone III (500-214 cc)

Zone III records increasing percentages of *Pinus* (40-63%), decreasing although relatively high percentages of Gramineae (5-30%), an increase in *Artemisia* (10-25%), and a consistent representation of Chenopodiineae and Composite (aster family). *Abies*, Cupressaceae, and *Alnus* also are present in significant amounts. The percentage of arboreal pollen is still relatively low in this zone (53-75%) although it has increased slightly from Zone II. Except for two peaks (at 490 and 270 cm), pollen concentrations are relatively low (5,000-18,000 grains/cc). From bottom to top, sediments in Zone III change from a banded gyttja to interbedded layers of gyttja and peat. Organic and carbonate content remains essentially the same as in Zone II.

High percentages of Gramineae and Artemisia indicate continued open conditions during this time. In fact, Zone III represents the most open vegetation in the Goose Lake record. Furthermore, the increase of Artemisia and the consistent representation of Compositae and Chenopodiineae suggest a shrub-steep type of vegetation. Increasing percentages of Pinus and Abies imply the presence of these conifers somewhat closer to Goose Lake than in Zone II. The change to a shrub-steppe vegetation occurred before the fall of Mazama ash, found from 428-440 cm in the Goose Lake core. Mazama ash is dated at 6700 B.P. (Mehringer et al. 1977). Similar pollen percentages are found in modern pollen samples collected from shrub-steppe environments south of the site on the Columbia Plateau (Mack and Bryant 1974).

Zone IV (214-10 cm)

In Zone IV, Pinus percentages are high (68-82%) while percentages of Graminae (2-9%) and Artemisia (4-9%) are relatively low. Picea, Abies, and Alnus are also present in significant amounts. The percentage of arboreal pollen is consistently high in this zone (80-90%). Pollen concentrations are high (6,000-46,000 grains/cc). Important aquatic taxa are Cyperaceae and Typha latifolia. The sediments change from bands of gyttja and peat to a banded peat to a layer of fine gyttja. Organic and carbonate percentages continue to fluctuate randomly.

Consistent, although lower, percentages of Artemisia and Graminae indicate the continued importance of the shrub-steppe vegetation at Goose Lake. Very high Pinus values together with increasing percentages of Picea and Abies suggest the encroachment of a conifer forest. A transitional steppe/forest vegetation is inferred although it is difficult to tell whether Goose Lake was located in a forest zone with open areas occupied by Artemisia and Gramineae or whether it was located in the steppe region, close to the forest boundary. Judging from the modern vegetation, the latter possibility seems more likely. Modern analogs are found both in the steppe region of the Columbia Plateau (Mack and Bryant 1974) and in the Pinus ponderosa-Symphoricarpos albus (Ponderosa pine-common snowberry) zone in northeastern Washington (Mack et al. 1978a). Nickmann (1979) observes a similar rise in the percentage of Pinus at Williams Lake Fen which he has dated at 4,060 ±300 years B.P.

Zone V (10-0 cm)

Zone V records a significant increase of Chenopodiineae (up to 35%)> Except for a slight decrease in Pinus and Gramineae percentages, the rest of the pollen rain remains essentially the same as observed in Zone IV. As a result of the increase of Chenopodiineae, the percentage of arboreal pollen decreases slightly (55%). The pollen concentration also decreases slightly (23000 grains/cc). Cyperaceae and Typha latifolia continue to be the major aquatic contributors. The sediment of Zone V is a fine gyttja with an organic content of 15 percent and a carbonate content of 28 percent.

The constant pollen percentages indicate that the vegetation remained essentially the same between Zone IV and Zone V except for the increase in Chenopodiineae. This increase also has been observed by Davis et al. (1977) in the pollen sequence at Wildcat Lake. They attribute this rise to the introduction of livestock at the end of the 19th century. Overgrazing resulted in the destruction of the natural vegetation and the subsequent proliferation of the weedy species. The Chenopodiineae peak also was observed in analyses of the Rex Grange and Seatons Grove cores.

CONCLUSIONS AND COMPARISONS

The pollen sequence at Goose Lake begins shortly after the retreat of the Okanogan Lobe of the Cordilleran Ice Sheet. It provides the following record of major climatic and vegetational changes in the area from approximately 12,000 years ago to the present time.

The first pollen record at Goose Lake exhibits high percentages of *Pinus* and *Picea*, derived mainly from long distance transport. Zone I also documents the establishment of the first local vegetation following deglaciation. This vegetation consisted of an open woodland comprised of various conifer and other arboreal species with open areas of Gramineae and *Artemesia*.

The sudden increase of Gramineae in Zone II reflects a change to warmer and dryer conditions. The increase of Gramineae together with the relatively high values of *Artemisia* are indicative of a grass-steppe vegetation. Low *Pinus* percentages are interpreted as representing *Pinus* forests at relatively great distances from the lake.

Zone III represents the most open vegetation in the Goose Lake record. The pollen evidence indicates continued warming and drying with the resulting establishment of a shrub-steppe type of vegetation. This warming and drying trend began well before the fall of the Mazama ash. Zone III represents the period of maximum warmth and dryness in the Goose Lake record. Increasing percentages of *Pinus* and *Abies* suggest that these trees have moved somewhat closer to Goose Lake.

High arboreal percentages, indicating cooler and moister conditions, are observed in Zone IV. During this time, the modern vegetation in the region was established. The consistent representation of *Artemisia* and Gramineae together with high *Pinus*, *Abies* and *Picea* percentages indicate a transitional steppe/forest vegetation.

The dramatic rise of Chenopodiineae in Zone V records the introduction of livestock at the end of the 19th century. Overgrazing resulted in the destruction of the natural vegetation and the subsequent proliferation of the weedy species.

Pollen zones (excluding settlement zones) from other eastern Washington sites are compared to the Goose Lake sequence in Figure 3-4. Such comparisons are useful for distinguishing regional as opposed to local vegetational and climatic changes. These comparisons are limited, however, and more pollen work should be done to gain a clearer regional picture. The terms describing inferred vegetation were modified to facilitate comparison across the region.

Years B.P.	Williams Lake (Nickman 1979)	Creston Mack et al. 1978	Goose Lake (Dalan 1979)	Big Meadow Mack et al. 1978	Inferred Climate
				V	
1000	V		IV	*Ts uga heterophylla* climax	
2000	transitional steppe/forest		transitional steppe/forest		cooler and moister
3000				IV *Abies, Picea Pinus* forest	
4000		II transitional steppe/forest	------?------		---?----
5000			III	III *Pinus/ Artemisia* forest	
6000	II-IV		shrub-steppe		warmer and drier
7000	grass-steppe		------?------		
8000			II	IIa-IIb transitional steppe/forest	
9000			grass-steppe ------?------		---?----
10000	I		I		
11000	*Pinus, Alnus, Artemisia* vegetation mosaic	I	open woodland	I tundra	
12000		*Pinus, Abies Picea, Artemisia, Gramineae* vegetation mosaic	------?------		cool and moist
13000					
14000					
		-----?------			

Figure 3-4. Pollen zone correlations for eastern Washington. Dashed lines indicate lack of radiocarbon date control.

Since no radiocarbon dates have been obtained for the Goose Lake core, the boundaries of the Goose Lake pollen zones are only gross estimates.

Goose Lake Zone I correlates with the first zone from all other sites. South at Williams Lake Fen and Creston Mire, Artemisia and Gramineae are more prominent. Vegetational mosaics are inferred, consisting of stands of various arboreal taxa with open areas occupied by Artemisia and Gramineae. At Goose Lake, the vegetation appears to be more densely wooded. To the north at Big Meadow, an alpine tundra is inferred although this was not convincingly demonstrated. An alpine or park-like vegetation just above timberline or a pioneer forest or shrub community which invaded the area after deglaciation are other possibilities (Mack et al. 1978b:961).

Zone II correlates with Zone II at Big Meadow and Williams Lake Fen. At both of these locations, simillar Gramineae peaks were observed. At Williams Lake Fen the inferred vegetation is a grass-steppe vegetation while at Big Meadow a transitional steppe/forest vegetation is documented. The Goose Lake vegetation, with an arboreal component more important than at Williams Lake Fen and less important than at Big Meadow, appears to be a transition zone between these two extremes. The bottom half of the second Creston Mire zone also correlates with these zones. A transitional steppe/forest vegetation is inferred for the rest of the pollen sequence. This sequence is difficult to compare to the other cores because zones were distinguished by changes in diploxylon and haploxylon pine percentages. Also, a major portion of the Creston core above the Mazama ash was disturbed.

Zone III correlates with Williams Lake Fen Zones III and IV and with Big Meadow Zone III. Williams Lake Fen records the continued presence of a grass-steppe vegetation while at Big Meadow a Pinus forest with a shrubby understory was established. All zones record a gradual increase of Pinus. Again, the nonarboreal component is more important at Williams Lake Fen, less important though still prominent at Goose Lake, and least important at Big Meadow.

Zone IV correlates with Williams Lake Fen Zone V and Big Meadow Zones IV and V. All zones show the increasing importance of the arboreal component. The Williams Lake Fen and Goose Lake records indicate a transitional steppe/forest vegetation. At Big Meadow, a Picea, Abies, Pinus forest is followed by a Tsuga heterophylla climax forest.

The climatic interpretation for all cores except the Creston core follows the same general sequence. A cool and moist period is followed by a warmer and dryer period and then a return to cooler and moister conditions. The change to cooler and moister conditions is not recorded at Creston Mire; however, the upper portion of the core was disturbed.

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4. A POSTGLACIAL POLLEN RECORD FROM GOOSE LAKE, OKANOGAN COUNTY, WASHINGTON: EVIDENCE FOR AN EARLY HOLOCENE COOLING

by Rudy J. Nickmann and Estella Leopold

This study examines in detail the fossil pollen record at Goose Lake, north-central Washington, from late glacial to early Holocene time. A core was collected from Goose Lake in conjunction with the Chief Joseph Dam Archaeological Project for the purpose of paleoenvironmental reconstruction. Initial palynological analysis (Dalan, Chapter 3) indicated the core contained a complete, well-preserved sequence dating back to late glacial times, including Mazama tephra. The core offered good potential for detailed study of vegetation stabilization in early post-glacial times and of the effects of Mazama ashfall on vegetation. Dalan's study (Chapter 3) reports 21 samples, analyzed by Nickmann, from the bottom of the core (650 cm) to 20 cm above the Mazama tephra (410 cm). For this study, an additional 82 samples were collected, providing a minimum sampling interval of 5 cm and finer intervals in selected areas, such as above and below the Mazama tephra.

A description of Goose Lake, its geographic setting, and the regional climate can be found in Dalan (Chapter 3). The Goose Lake site is particularly useful for environmental reconstruction because it is on a sensitive ecotonal boundary between the grass dominated steppe of the northern Columbia Basin and the forested regions of the Okanogan Highlands (see Figure 3-1). Shifts in this boundary should be recorded more dramatically at Goose Lake than at sites deeper within the forested zones. Nine zonal associations, differentiated in response to variations in temperature and total and seasonal distribution of precipitation, have been recognized in the Columbia Basin. The five associations found on the moister periphery of the steppe region near its contact with forest vegetation tend to be lush, meadow-like communities, with conspicuous amounts of large perennial grasses and broad-leaved forbs (Franklin and Dyrness 1973). Goose Lake lies within one of these, the *Artemisia tripartita-Festuca* zone, characterized by *Artemisia tripartita* (threetip sagebrush) and a continuous herb layer of which *Festuca idahoensis* (blue bunchgrass) is a member. If *A. tridentata* is present, it is confined to disturbed areas (Daubenmire 1970). The shrub steppe vegetation surrounding Goose Lake grades into *Pinus ponderosa* (Ponderosa pine) forest. *P. ponderosa* is able to occupy drier sites than any other forest type except *Juniperus occidentalis*. At higher elevations, the *Pinus* forest grades into forests of *Pseudotsuga menziesii* (Douglas fir) and *Abies grandis* (Grand fir) (Franklin and Dyrness 1973).

METHODS

Collection of the core and initial handling of the core in the laboratory is described by Dalan (Chapter 3). This analysis incorporates the 21 samples between 410 cm and 650 cm, analyzed by Nickmann, which are reported by Dalan (Chapter 3). An additional 82 samples were collected. Figure 4-1 shows the sampling intervals. The entire core below 410 cm was sampled at 5-cm intervals (with the exception of the tephra itself) and several areas were more finely sampled. The section between 450 and 500 cm is sampled at 2-cm intervals, and the sections between 570 and 590 cm and between 410 and 450 at 1-cm intervals. Sampling in the laboratory consisted of packing 1/2 cc of sediment into a calibrated syringe using a small spatula. Three samples were taken at each sampling level and stored in snap-top polyethylene vials.

Loss on ignition was determined by igniting dried sediment samples for two hours at 600°C. This provides a rough approximation of the amount of organic matter, with the organic carbon usually equalling 40-60% of the loss on ignition (Berglund 1979:116). The same samples were then ignited for two hours at 900°C. The additional weight loss incurred provides an approximation of the biological carbonate present (Mehringer et al. 1977a).

Pollen samples were processed using the standard KOH-HF acetolysis treatment (Faegri and Iversen 1964) and mounted in 2000 centistroke silicon oil. Routine pollen counting was accomplished at 400X. Haploxylon determinations were made at 1000X using an oil immersion lens.

Pollen percentages shown in the pollen diagram (Figure 4-1) are based on two sums. Nonaquatics, both arboreal (AP) and nonarboreal (NAP) types are included in the pollen sum (P). Aquatics are computed using P + aquatics as a sum. This division is an attempt to separate pollen of regional significance from that derived from plants influenced by the local hydrology and/or vegetational succession of the lake itself. Pollen in the column titled "other" includes grains so badly damaged as to make identification impossible and grains that are well preserved but could not be placed into a proper taxonomic grouping. Pollen preservation is generally good. In Pollen Zone I, most of the unknowns appear to be Cyperaceae or Gramineae that are so badly abraded and corroded that they couldn't be identified with any degree of certainty.

Pinus pollen grains are vesiculate, consisting of a body (corpus) and two bladders (air sacs). Often, one or both of these bladders break loose from the body. _Pinus_ grains were counted as either whole, bodies with one bladder, bodies, or individual bladders. After a sample was counted, the bladders were distributed among the bodies and bodies with one bladder. If an excess number of bladders remained, they were divided by two and counted as additional whole pines. The _Pinus_ profile in the diagram is divided into whole pines, which represent complete unbroken grains, and broken pines, the number of which was computed in the aforementioned manner. Haploxylon and diploxylon percentages were determined using 50 grains as a sum. The Chenopodiineae include both Amaranthaceae and Chenopodinaceae.

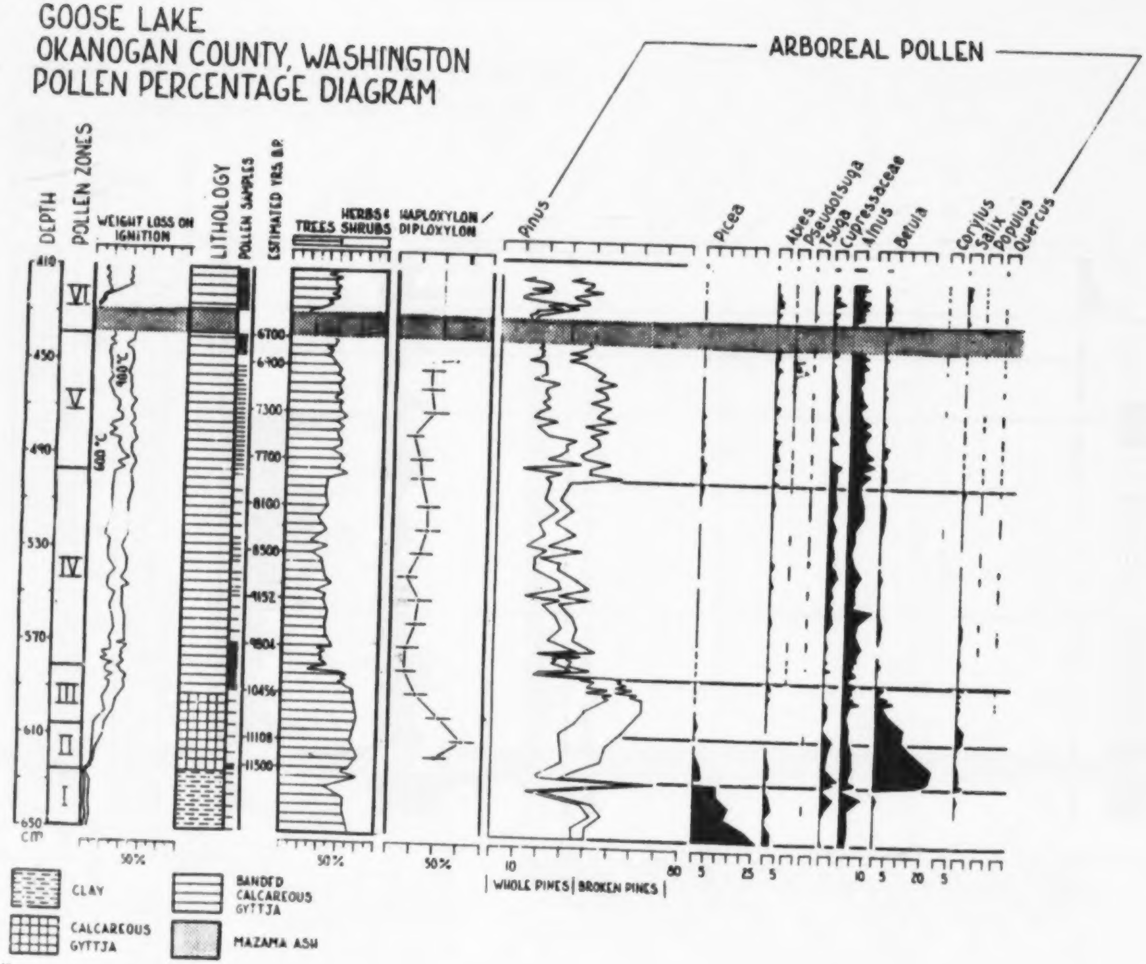

Figure 4-1. Pollen diagram from the Goose Lake core (650-410 cm), Okanogan County, Washington

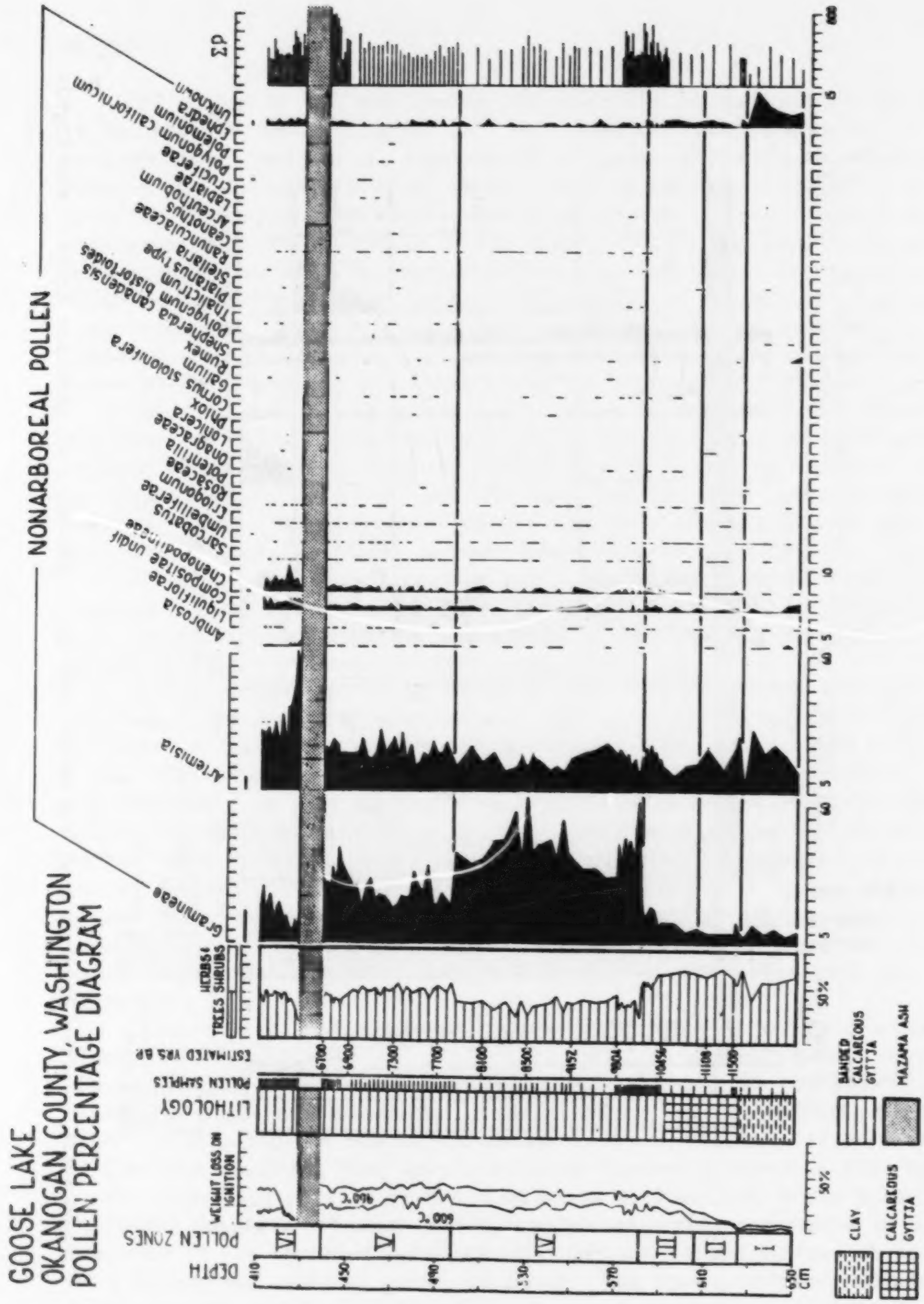

Figure 4-1, cont'd.

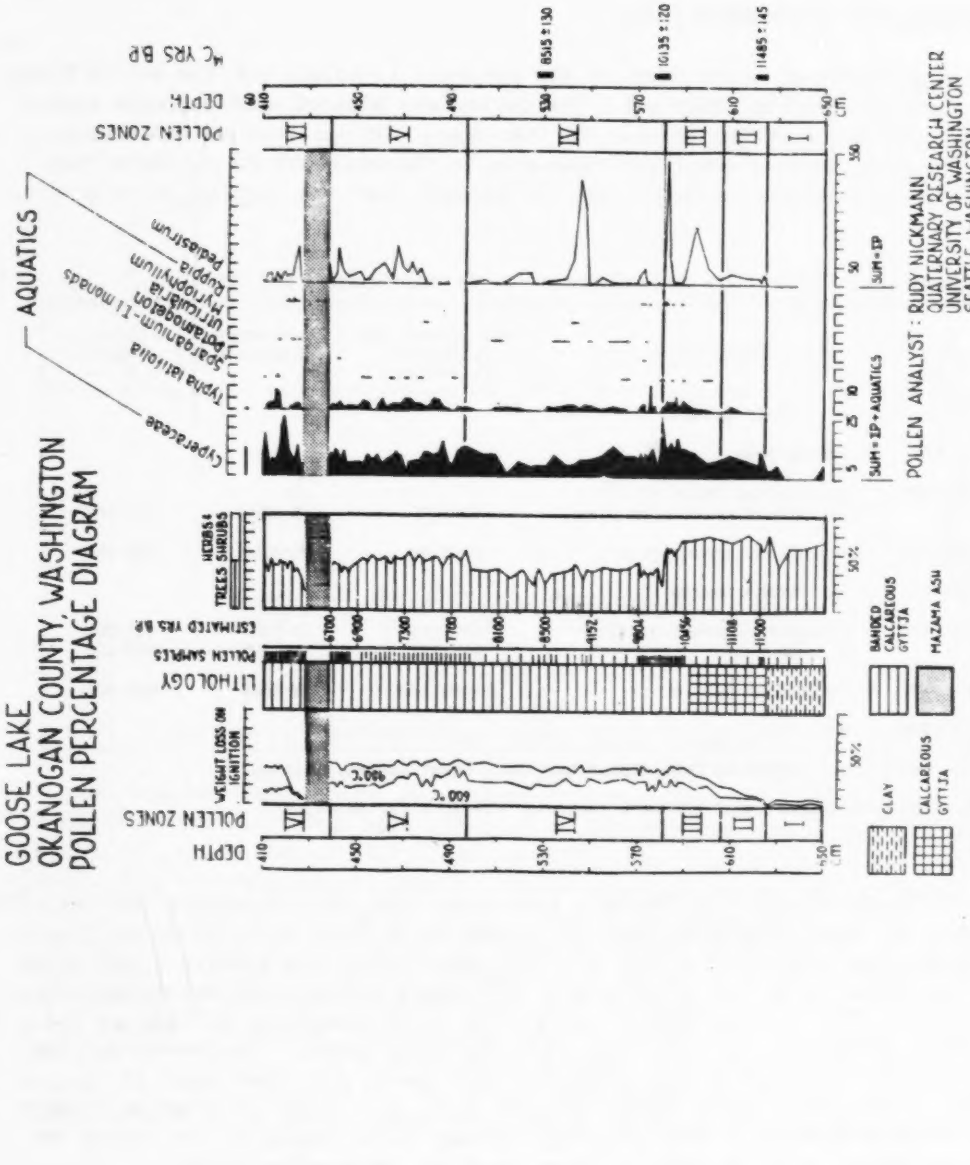

Figure 4-1, cont'd.

The pollen spectrum from a depth of 60 cm is shown at the top of the diagram. A preliminary study indicates that this sample lies immediately below the Euroamerican cultural disturbance horizon and can be taken as a "modern pollen surface spectrum". Samples taken above this level show very high Chenopodiineae values probably resulting from range degradation and the proliferation of weedy species.

SEDIMENTS AND RADIOCARBON DATES

A generalized description of the sediment lithology for the entire Goose Lake core is given in Table 4-1. The coring was stopped when we were unable to physically force the sampler further down. No positive evidence (e.g., sand, gravel, stones, etc.) was recovered in the sediment to indicate that bedrock was reached. Nevertheless, it appears that the section is relatively complete.

Table 4-1. Lithology and radiocarbon dates, Goose Lake core.

Depth (cm)	Description	Radiocarbon Age (Years B.P.) T1/2=5568	Laboratory[1] Sample #	Sample Interval[1]
0-37	Fine brown gyttja			
37-109	Banded peat			
109-289	Alternating bands of calcareous gyttja and peat	4755±85	B-1292	212-218
289-428	Banded calcareous gyttja	9580±90	B-1293	327-333
428-440	Mt. Mazama tephra			
440-592	Banded calcareous gyttja	8515±130 10135±120	B-1294 B-1295	527-533 577-583
592-625	Calcareous gyttja	11485±145	B-1296	620-625
625-650	Grey clay			

1. Samples were dated by Beta Analytics, Inc., Coral Gables, Florida.

2. The entire section of the core indicated was sent for dating.

Selected segments of the core were submitted for radiocarbon dating. The results of these determinations are presented in Table 4-1. Although the sediments are highly calcareous and gastropod shells are numerous, the dates are consistent with the stratigraphy and tephra dating with one exception. The radiocarbon date of 9580±90 (Beta 1293) from a depth of 327-333 cm is rejected because it is discordant with the other dates. The Mazama ash has been previously dated at approximately 6700 years B.P. (Mehringer et al. 1977b). Estimated years before present (B.P.) on the pollen diagram (Figure 4-1) were determined by extrapolating between dated segments, including the Mazama tephra layer as well as those dated by radiocarbon dates.

Figure 4-2 shows the relationship between the Goose Lake radiocarbon dates and sediment depth. Sedimentation was slowest between 625 and 530 cm (approximately 32 yrs/cm) and most rapid between deposition of the Mazama ash and 215 cm (approximately 9 yrs/cm). Extrapolating a sedimentation rate of 32 yrs/cm into the lower clay unit gives a date of 12,285 yrs B.P. at the bottom of the core.

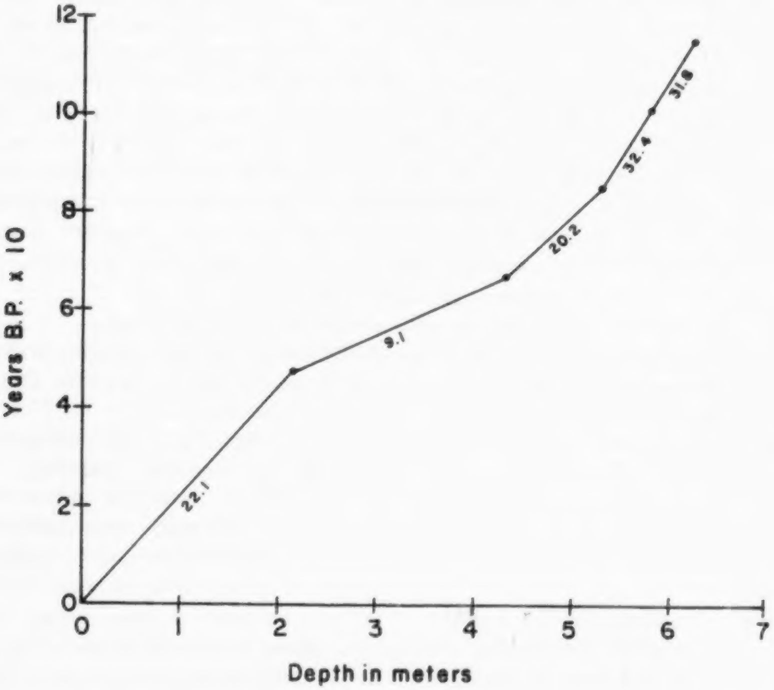

Figure 4-2. Sedimentation rate, Goose Lake core.

No Glacier Peak tephra was observed in the core. The multiple eruptions of Glacier Peak ash have been dated at 11,200±300 yrs B.P. (Mehringer et al. 1977b), 12,000-13,000 yrs B.P. (Lempke 1975) and 12,000±310 yrs B.P. (Fryxell 1965). Glacier Peak ash is found in cores from Big Meadow (Mack et al. 1978b), Williams Fen (Nickmann 1979), Waits Lake (Mack et al. 1978d) and Creston Fen (Mack et al. 1976). At Simpsons Flats (Mack et al. 1978a) and Hager Pond (Mack et al. 1978c) sediments old enough to contain Glacier Peak ash apparently were not recovered. Glacier Peak ash is not found at the three sites closest to Glacier Peak, Goose Lake, Mud Lake, and Bonaparte Meadows (Mack et al. 1979). This may indicate an anomalous distribution of ash, or simply that the formation of, and active sedimentation within, these three basins didn't occur until immediately after the Glacier Peak eruptions.

The geological history of the Goose Lake area should be examined in more detail to determine the condition of the area at the time of the Glacier Peak eruptions. The lake is at the southern end of the Omak Trench, a previous channel of the Columbia River enlarged and deepened during the Late Pleistocene by the Okanogan Lobe of the Cordilleran Ice Sheet. At its maximum, the thickness of ice over the Goose Lake site exceeded 1200 m (Richmond et al. 1965). According to Hibbert (Chapter 2), Goose Lake lies in a flood-cut channel which cuts the outwash plain built as the Okanogan Lobe retreated. The flood is undated, although it is known that the Columbia River was at an elevation lower than 1200 ft at the time. Hibbert suggests that a later impoundment created a lake with a surface elevation of 1280 ft which extended up the Omak Trench and up the canyon of the Columbia River toward the Grand Coulee. Deposits associated with this lake include bedded sands in the mouth of the flood-cut channel in the Omak Trench, and the anomolous 1240 ft terrace which is not capped by Columbia River Gravels. Hibbert does not discuss the geological events post-dating this lake. The elevation of Goose Lake is 1225 ft, indicating that the lake sediments either did not fill in the channel or the channel was re-incised when the lake drained. It seems likely that the lowest sediments in the Goose Lake core, 25 cm of gray clay, were deposited in a smaller lake basin, formed immediately after the Glacier Peak eruptions, that did not extend into the main canyon.

Close examination of the Mazama ash indicates that considerable disturbance of the ash stratigraphy has occurred, probably during transportation of the core. A thin (<1mm) layer of brown organic material is noted near the middle of the ash unit. This may indicate the fall of two individual ashes separated by a very brief interval of organic lake sediment deposition.

Banding, presumably the result of fluctuations in lake level and/or changes in runoff or lake productivity, is prominent and extensive in the core. Organic and carbonate determinations, while showing some minor fluctuations, remain relatively constant throughout the core. Both values are lowest in the clay lithologic unit at the bottom of the core and immediately above the Mazama ash.

RESULTS

Pollen zones determined by visual inspection of the pollen diagram are described individually below. Table 4-2 shows the relative frequency of selected taxa by zone. Note that these zones are not equivalent to Dalan's (Chapter 3) zones. Zones I, II, and III here (650-581 cm) correspond with Dalan's Zone I (650-585). Zone IV here (581-497 cm) corresponds with Dalan's Zone II (585-500 cm). Our Zones V and VI (497-410 cm) are equivalent with the lower third of Dalan's Zone III (500-214 cm).

Table 4-2. Average percentages of selected pollen types by pollen zone (see Figure 4-1 for depth of zones.

Pollen Zone	# of Samples	*Pinus*	*Picea*	*Betula*	Gramineae	*Artemisia*	Compositae[1]	Chenopod-iineae
VI	18	31.3	0.4	1.1	13.0	33.2	4.4	4.8
V	32	40.4	0.6	0.8	24.1	18.6	1.7	1.6
IV	29	31.6	0.4	0.6	41.5	13.9	1.1	1.1
III	13	56.9	0.6	4.2	11.6	14.8	1.6	1.1
II	5	38.0	1.8	20.1	5.9	18.4	1.5	0.7
I	6	43.7	16.0	5.1	5.3	15.2	2.2	0.1

[1] Compositae includes both Liguliflorae and *Ambrosia*.

Pollen Zone I (>11,500 yrs B.P.; 650-625 cm)

Pinus-*Picea*-*Artemesia*

The fossil pollen assemblage in Zone I is dominated by *Pinus*, *Picea* and *Artemisia*. *Pinus* values are quite variable, ranging from a low of 21% to a high of 69% at a depth of 626 cm. The total number of pine grains with undamaged or visible distal membranes were too few to make haploxylon-diploxylon determinations. *Picea* ranges from 27% at the bottom of the core to 10% at the top of Zone I. *Artemisia* ranges between 27 and 4%. Other NAP contributing more than 1% include *Ambrosia*, Compositae undif. and *Shepherdia canadensis*. Minor AP elements include *Abies*, Cupressaceae and *Alnus*. Gramineae remains around 5%.

Pollen Zone II (11,500-10,975 yrs B.P.; 625-606 cm)

Pinus (haploxylon), *Betula*, *Artemisia*

Pinus, *Betula* and *Artemisia* dominate Pollen Zone II. *Pinus* increases from 30% at the bottom of the zone to almost 64% at the top. Haploxylon pines make up to 78% of the fossil pine grains. *Betula* appears suddenly at the base of the zone, reaching 24% at 617cm. *Picea* falls to under 5%. Cupressaceae, *Abies*, *Salix* and *Alnus* are minor AP elements. Gramineae averages around 5%. Other NAP contributing more than 1% Compositae undif. and Chenopodiineae. Cyperaceae reaches almost 10% while *Typha latifolia* makes its first appearance in the core. Pediastrum is first recorded consistently here, averaging around 25%.

Pollen Zone III (10,975-10,160 yrs B.P.; 606-581 cm)

Diploxylon pine, *Betula*, *Artemesia*

Diploxylon pines, *Betula*, Gramineae and *Artemisia* are the main contributors to the fossil pollen assemblage found in Pollen Zone III. *Pinus* ranges between 52 and 60%. *Betula* declines from approximately 10% at the base of this zone to trace values at the top. Other minor AP elements include Cupressaceae, Alnus, and Salix. Gramineae averages near 5% at the base of Pollen Zone III, rising to near 15% at the top. Artemisia fluctuates between 8 and 20%. Compositae undif. and Chenopodiaceae are the only other NAP contributing over 1%. Cyperaceae and Typha latifolia are the major aquatics, while Sparganium and Ruppia make their first appearance. There are two major Pediastrum peaks: 150% at 595 cm and 325% at 583 cm.

Pollen Zone IV (10,160-7860 yrs B.P.; 581-497 cm)
Gramineae, diploxylon pine, Artemisia

Diploxylon pines, Gramineae and Artemisia dominate this zone. Pinus drops precipitously from the top of Zone III to the base of Zone IV (52% to 23%). Cupressaceae and Alnus are minor AP elements. Gramineae rises concurrently with the fall of Pinus (12% to 61%). Gramineae are quite variable, although remaining high. There are major Gramineae peaks at 525 cm (55%), 530 cm (63%), 546 cm (53%) and 580 cm (61%). Artemisia varies between 9 and 21%. Compositae undif. and Chenopodiineae are minor NAP elements. Cyperaceae and Typha latifolia are the major aquatic elements, while Sparganium, Potamogeton, Utricularia, Myriophyllum and Ruppia are occassionally present. Pediastrum values are generally low, although a major peak (275%) occurs at 546 cm.

Pollen Zone V (7860-6700 yrs B.P.; 497-438 cm)
Diploxylon pine, Gramineae, Artemisia

Diploxylon pines, Gramineae and Artemisia dominate the fossil pollen record in Zone V. Pinus values increase approximately 10% from those in Zone IV. Alnus and Cupressaceae are minor AP contributors. Although present in low values, generally under 2%, Picea and especially Abies become more consistent than in Zone IV. Gramineae is quite variable, between 16 and 41%, but remains lower than in Zone IV. Artemisia varies between 12 and 27%. Compositae undif. and Chenopodiineae are minor NAP elements. Once again, Cyperaceae and Typha latifolia are the important aquatics. Pediastrum is absent or found only in trace amounts below 480 cm, but becomes more prevelent towards the top of the zone.

Pollen Zone VI (6700-6350 yrs B.P.: 438-410 cm)
Artemisia, Pinus, Gramineae

Artemisia dominates Pollen Zone VI. Immediately above the Mazama ash, it reaches 62%, a threefold increase from values taken just beneath the ash. It falls rapidly within a few centimeters to under 30%. As it decreases, both Pinus and Gramineae increase. Compositae undif. and Chenopodiineae have their highest values and are more consistent here than in any other zone. Typha latifolia and Cyperaceae are the major aquatics. Minor aquatic elements include Sparganium, Utricularia, and Ruppia.

DISCUSSION

POLLEN ZONE 1

The most noteworthy feature of Pollen Zone I is the high *Picea* values. The *Picea* grains are generally in an excellent state of preservation, probably ruling out the possibility that they were derived from reworked sediments. Previous studies in eastern Washington show early postglacial *Picea* values of less than 5%. *Picea engelmannii* is found today associated with climax forests of *Abies lasiocarpa* in the subalpine forest zone of eastern Washington, particularly in frost pockets and glaciated valley bottoms into which cold air drains and accumulates (Franklin and Dyrness 1973). However, the high *Picea* percentages noted at Goose Lake may be deceptive, the result of long distance pollen transport into a region of herb dominated vegetation with low pollen influx. At Big Meadow, Mack et al. (1978b) found evidence for a tundra-like landscape with low pollen influx from the time of deglaciation until ca. 9700 years B.P. Prior to 10,000 years B.P., trees were not a major component of the vegetation at Waits Lake (Mack et al. 1978d). Evidence from Mud Lake (Mack et al. 1979) indicates that between 11,000-10,000 years B.P. vegetation was open with few trees. The earliest pollen zones at Simpsons Flats (10,000-ca. 9000 years B.P.) and Creston Fen (ca. 11,500-9400 years B.P.) were interpreted as being produced by a largely treeless vegetation (Mack et al. 1978a and Mack et al. 1976). With relatively open or tundra-like vegetation to the north and south of Goose Lake during deposition of Pollen Zone I, it seems reasonable to assume that a similar situation existed at Goose Lake.

Pollen Zone I encompasses the silt lithologic unit found at the base of the core. Pollen concentration here is relatively low. In most cases, several slides had to be counted to arrive at satisfactory pollen sums. Assuming that the sedimentation rate was not abnormally high, the low pollen concentration probably confirms that pollen influx was indeed low.

Apparently, during deposition of Pollen Zone I, the vegetation around Goose Lake was relatively open and dominated by herbs and shrubs. Small isolated stands of *Pinus* and *Picea* may have been present locally on favored sites. The low productivity of the lake itself is shown by the lack of any appreciable organic fraction in the sediment and the absence of aquatics and Pediastrum.

POLLEN ZONE II

Pollen Zone II is marked by a dramatic increase in *Betula* that coincides with a shift from clay to calcareous gyttja deposition. Mack et al. (1979) noted a contemporaneous rise in *Betula* at Mud Lake. The *Betula* pollen probably reflects birch species growing on moist sites scattered throughout the landscape and perhaps around Goose Lake itself. *Salix* also appears in this zone and most likely grew along streams and bordering small ponds and lakes.

The pines found in this zone are composed of up to 75% haploxylon types. The two haploxylon types found in eastern Washington today, P. monticola and P. albicaulis both grow in cooler and moister environments than found at Goose Lake today. As previously mentioned, pines produce tremendous amounts of pollen. The percentages found in Zone II don't indicate the local presence of pine forest.

Although doubtless cooler than today, the presence of Typha latifolia pollen in Zone II implies that a tundra environment did not exist at this time around Goose Lake. Birks (1976) reports that cattails are not found in the Arctic today.

Lake productivity increases noticably in this zone with the appearance of Pediastrum and the increase of organic matter found in the lake sediments.

POLLEN ZONE III

Betula declines in Pollen Zone III while Pinus rises. Diploxylon pines, probably Pinus contorta and/or P. Ponderosa, increase steadily. This probably indicates climatic conditions slightly warmer and drier than those found in Pollen Zone II.

POLLEN ZONE IV

A spectacular increase in Gramineae marks the onset of Pollen Zone IV. The Goose Lake core was sampled at one centimeter intervals across the boundary between Pollen Zones III and IV in order to determine the rate at which this Gramineae rise occurred. The results are shown below:

DEPTH (cm)	Pinus	Gramineae
580	22.2%	60.8%
581	51.7	20.4
582	54.8	12.0

Although Gramineae does increase between 582 and 581 cm, most of the rise occurs in the threefold increase between 581 and 580 cm. Assuming a sedimentation rate of 32 cm/yr as calculated using the available radiocarbon dates, it appears that this shift in the fossil pollen rain took place in 32 years or less. At William Fen, using a sampling interval of 10 cm, Nickmann (1979) notes a similar sharp rise in Gramineae at approximately the same time (9520±400 years B.P.).

A dramatic and contemporaneous change in the fossil pollen record has been noted in other regions of North America. Ogden (1967) reviews radiocarbon and pollen evidence for a sudden change in climate in the Great Lakes region and New England approximately 10,000 years ago. None of these sites was sampled in such great detail across this critical boundary as was Goose Lake. At Glacial Lake Aitkin, Minnesota, it was estimated that the replacement of spruce pollen by other pollen types took place within approximately 170 years.

Pinus drops off sharply in Pollen Zone IV and is dominated by diploxylon types. *Pinus ponderosa* and/or *P. contorta*, the two diploxylon pines found at lower elevations and drier environments of eastern Washington, probably are the most significant contributors to the *Pinus* profile in Zone IV. As previously noted, pine produces abundant pollen and is usually overrepresented in the fossil pollen record. Mack and Bryant (1974) in a study of modern pollen spectra in the Columbia Basin, report *Pinus* values of over 10% near the center of the Columbia Basin, 100 km from the nearest pine forests. The values found in Zone IV don't indicate the nearby presence of substantial stands of pine.

The pollen horizon at 60 cm contains *Pinus* values over twice as high and Gramineae and *Artemisia* value over twice as low as in Pollen Zone IV. This implies that climatic conditions during deposition of Pollen Zone IV were substantially warmer and drier than those found today at Goose Lake. There are additional changes in the fossil pollen record that point toward relative warmth and aridity. *Betula* and *Salix*, both of which grow in locally moist situations, decrease. *Quercus*, probably *Q. garryana*, which grows today on the dry eastern slopes of the Cascade Range, appears here. *Ruppia*, found in brackish and saline ponds, occurs at the boundary between Zones III and IV. An increase in evaporation may have lowered the lake level and increased salinity, favoring growth of this taxon.

It is of some interest to speculate on what may have caused such a sudden and dramatic change in the climate and the concurrent development of grass-steppe vegetation in the Goose Lake area. Prior to ca. 10,000 years B.P., the Cordilleran ice sheet was located just north of the U.S.-Canadian border (Richmond et al. 1965). Persistent high pressure systems of thermal origin are found today over the icecaps of Greenland and Antarctica. From the highest portion of ice plateau and from the center of the high pressure system, a shallow layer of cold gravity winds drains downslope towards lower marginal areas. These katabatic winds dominate circulation over the icecaps and along the steep margins of the ice sheet, locally reaching gale force. We may assume that they existed on the margins of the Cordilleran ice sheet. These northerly winds may have been strengthened as they were channeled down the North-South trending Okanogan Valley. After ca. 10,000 years B.P., the ice sheet continued to abate rapidly. The cold high pressure system that had dominated the atmospheric circulation for some distance to the south of the ice sheet terminus grew weaker and retreated northward with the shrinking ice sheet. As modern wind and pressure systems asserted themselves, the prevailing southwesterly winds found today at Goose Lake supplanted what had been a predominately northerly flow. Not only did this change in prevailing winds signal a sudden change in climate, the winds themselves brought pollen from a different source region. Instead of carrying pollen from the open or tundra-like vegetation located just to the south of the ice edge, it carried pollen from the grass-steppe that was rapidly advancing from the south of Goose Lake. In fact, if open vegetation with a low pollen influx still existed immediately around Goose Lake, it would have been swamped in the fossil pollen record by the more abundant pollen from the grass-steppe. This may have given the appearance that grass-steppe vegetation arrived at Goose Lake somewhat earlier than it actually did.

POLLEN ZONE V

The period between 7,800-6,700 years B.P. (Pollen Zone V) is marked by an increase in *Pinus* and a decrease in Gramineae. Haploxylon pines and *Artemisia* increase slightly. *Picea* increases to over 1% in the bottom half of Zone V, and *Abies* becomes more consistent than in the underlying Zone. Apparently, an increase in available effective moisture allowed the surrounding forests to descend to lower elevation.

These results are quite unexpected. Similar evidence for possible cooler and/or moister conditions during the 1,000 years prior to the fall of Mt. Mazama ash in eastern Washington has not been reported. Previous pollen studies have been interpreted as demonstrating a continuous warm and dry hypsithermal interval starting as early as 9,700 years B.P. (Big Meadows, Mack et al. 1976) and as late as 8,000 years B.P. (Simpsons Flats, Mack et al. 1978a) and terminating between ca. 5,000 years B.P. (Waits Lake, Mack et al. 1978d) and ca. 3,000 years B.P. (Hager Pond, Mack et al. 1978c). Other lines of evidence, such as faunal remains (Gustafson 1972) give no direct evidence for a warm and dry Hypsithermal Interval in the Columbia Basin. Waitt (personal communication, U.S.G.S.) has found tentative evidence for glacial readvance in the Enchanted Lakes region of the Cascades at about 8,000 years B.P.)

POLLEN ZONE VI

An apparent unconformity immediately below the Mazama ash has been described at Simpsons Flats (9,000-6,700 years B.P., Mack et al. 1978a) and Bonaparte Meadows (8,300-6,700 years B.P., Mack et al. 1979). The authors suggest that this unconformity, which may have been undetected at other sites, could represent a lowering of the local water table and deflation of organic sediments prior to deposition of Mazama ash. These missing portions of the fossil pollen record at other sites complicates any direct comparisons with Goose Lake. Nevertheless, close inspection of the Mud Lake section (Mack et al. 1979) reveals an increase in *Pinus* and a decrease in *Artemisia* between ca. 8,000 years B.P. and Mazama ash deposition. This part of the fossil pollen record is included in the upper part of Pollen Zone M.L. II (10,000-6,700 years B.P.) and not differentiated. A close comparison of the Mud Lake pollen diagram with that of Goose Lake offers other interesting similarities such as an increase in haploxylon pines just prior to deposition of the Mazama ash and a very slight increase in *Picea* and *Abies* at comparable stratigraphic levels.

The core was sampled at 1-cm intervals below (9 samples) and above (18 samples) the Mazama ash to study the effects that the ashfall may have had on the vegetation surrounding Goose Lake. An impressive, short-lived rise in *Artemisia* is noted at the base of Pollen Zone VI, immediately above the ash.

Below the ash, Artemisia averages about 20%. The two samples immediately above the ash show a rise to approximately 60%. This threefold increase took place at the expense of Pinus and Gramineae. Compositae undif. and Chenopodiineae also show an increase immediately above Mazama ash. A similar rise in Artemisia is observed at Waits Lake (Mack et al. 1978d), Hager Pond (Mack et al. 1978c), and Big Meadow (Mack et al. 1978b). Mehringer et al. (1977a) attribute a short-term increase in Artemisia pollen influx at Lost Trail Pass Bog, Montana to a possible mulching effect of the ashfall on some sagebrush steppe genera.

Dalan's work on the upper part of the core indicates that Artemisia reaches its maximum values between 225 and 410 cm. This complicates interpretation of the sharp Artemisia rise above the Mazama ash since it means that this bulge is superimposed upon a curve that is in the process of rising already. The greatest shift in the fossil pollen record occurs in the first two centimeters above the ash. Seven centimeters above the ash (422 cm), Pinus and Artemisia values are comparable to those immediately below the ash. Assuming an average sedimentation rate of 9.1 years/cm between deposition of the Mazama ash and a depth of 215 cm as calculated using available radiocarbon dates, it appears that the major disruption in pollen rain lasted less than 18 years (2 cm). After approximately 63 years (7 cm), the effects of the ashfall on pollen rain had ended completely. These figures both represent maximum values. It is difficult to be certain of the sedimentation rate immediately above the ash, especially when probable disturbance caused by the thick ash layer on the landscape is taken into account. Sedimentation rates probably increased as the loosely compacted ash was carried into the lake basin both by surface runoff and ash laden wind. The drop in weight loss on ignition above the ash is probably due to an increase in silica of ash origin.

CONCLUSIONS

The postglacial and early Holocene fossil pollen record from Goose Lake adds new detail to our understanding of the paleoecology of eastern Washington. At the same time, it raises more questions and suggests possible avenues for future research. It seems that the Hypsithermal (ca. 9,000-3,000 years B.P.), while certainly warmer and drier than at present, had a more complex and variable history than previously imagined. The relatively cool and moist interval recorded at Goose Lake from 8,000-6,700 years B.P. may not have been apparent at other sites for two reasons: (1) An unconformity exists at many previously studied sites for this same time interval; and (2) The Goose Lake site, located in a narrow ecotonal region, has been especially sensitive to paleoclimatic variations.

Pollen from additional sites within the Pinus ponderosa-steppe ecotone of eastern Washington should be analyzed to duplicate and confirm the results found at Goose Lake. To avoid the unconformity found in many bogs, relatively deep lakes that probably have never dried out and should contain complete sedimentary records, are preferred sites. In addition, lakes such as Goose Lake and Waits Lake, which contain abundant gastropod shells, present the opportunity of O^{16} and O^{18} isotopic ratio determinations, offering the possibility of independent paleotemperature reconstructions.

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5. PALEOENVIRONMENTAL RECONSTRUCTION AND THE SEDIMENTARY SEQUENCE AT EXCAVATED SITES

by Sarah K. Campbell

In this chapter, sedimentary sequences at excavated sites are described and related to regional paleoenvironment, particularly the paleoenvironmental reconstruction developed by Chatters (1984c). Emphasis is on a regional perspective, in contrast to discussions of sedimentary sequences presented in the individual site reports, which focus on dating and separation of cultural occupations at individual sites.

REGIONAL PALEOENVIRONMENTAL RECONSTRUCTION

Regional paleoenvironmental data play two major roles in interpretation of regional prehistory. In seeking explanations for change in cultural adaptations, we consider environmental change as one possible factor. We also make assumptions about regional climate and physiography in order to interpret depositional environments and the formation of individual site deposits and the regional archaeological record. For example, Mierendorf (1983) discusses the implications of patterning in fluvial processes for prehistoric settlement, and for preservation and discovery of prehistoric remains.

The time period of interest is the Holocene, or postglacial, epoch (10,000 B.P. to the present), to which all known human occupation of the area can be ascribed. In the northern Columbia Plateau area, available sources of historical data relating to Holocene environments include fossil pollen studies, interpretations of soils and sedimentary sequences, studies of montane glacier activity, and archaeological materials.

A number of fossil pollen studies have been carried out in the northern Columbia Plateau area. Many of the primary studies are mentioned in Chapters 3 and 4, and a more current summary can be found in Chatters (1984c). Reviews from broader regional perspectives can be found in Baker (1983) and Mehringer (1985).

Numerous geologic studies focus on the history of Columbia Plateau glaciation and associated catastrophic flood events of the Pleistocene. The Holocene deposits relevant to archaeological research, formed by geologic events less catastrophic and more local in scale, have been of less interest to geologists. In fact, most studies of Holocene sediments have been conducted in connection with archaeological research (e.g., Cochran 1978; Fryxell 1973; Fryxell and Daugherty 1962; Hammatt 1977; Marshall 1971).

Although quantities of dated fossil material from archaeological sites far exceed quantities of other kinds of data collected, the contents of cultural sites can be used only with great caution for purposes of paleoenvironmental reconstruction. Because of the influence of cultural activities, proportions of plants and animal remains at archaeological sites are unlikely to reflect their proportional occurrence in the environment. Sedimentary deposits at archaeological sites also are affected by cultural activities, but to a lesser extent. The goal of site stratigraphic analysis generally is to identify natural depositional units that can be used to provide an independent chronological ordering of materials and correlation between different areas. It usually is possible to distinguish the contributions of cultural and natural processes in deposits; therefore, it is reasonable to use site sedimentary data for paleoenvironmental reconstruction. The greatest bias is in how the sample was selected; i.e., the sequences are from particular kinds of locations favored for human use and not representative of depositional environments in the area.

Based on the sedimentary sequence from RM 590 sites, published sedimentary sequences of other areas of the Columbia and Snake Rivers, and northern Plateau pollen profiles, Chatters (1984c:89-98) proposes the following detailed paleoenvironmental reconstruction, for the Columbia Plateau but focused on the Chief Joseph Dam Project area.

Late glacial climatic conditions obtained from 13,000 to 10,000 B.P., with a nearly treeless steppe/tundra type vegetation, dominated by a cold adapted form of Artemisia and with scattered groves of whitebark or limber pine, spruce, and fir in sheltered sites and birches and willows along streams and kettle lakes. The pollen influx was low. Early postglacial grasslands and forest began to grow between 10,000 and 9,000 B.P. and a warming and drying trend began between 9,000 and 8,000 B.P. Maximum aridity occurred between 8-7,000 B.P. and 4700-4000 B.P.

Prior to 6700 B.P. the river downcut rapidly through glaciolacustrine sediments and formed the T2 and T3 terraces. Due to its steep gradient the river was rapidly flowing and was probably a braided stream with constantly shifting channels.

From some time before 6700 B.P. until 4700 B.P. there was minimal floodplain aggradation, a largely unvegetated, barren landscape, and lower river levels than between 4700 and 2500 B.P. The low river flowed across a wide, gravelly bed and although not subject to extremes in annual flooding was perhaps prone to flash floods. During this time loess was deposited on the T2 and T3 terraces. The river was neither actively eroding through Nespelem Silt, nor laying down fresh floodplain sediments, so the aeolian sediments were derived from wind erosion on the largely unvegetated landscape. Many small streams had become intermittent and were subject to flash floods, building alluvial fans on terraces. A buried soil with a shallow calcium and silica rich B horizon dated between 5000 and 4000 B.P. indicates stable surfaces at this time, perhaps related to a cooling episode around 5000 B.P.

Moister conditions returned between 4700-4000 B.P. and 2700-2500 B.P. The record of montane glaciation shows an advance during the later part of this period, 3500 to 2500 B.P. Between 4700 and 4500 B.P. the Columbia River began to aggrade its floodplain, forming a low terrace. The river was characterized by higher water levels than in the previous period, and a wider floodplain. It had a greater flow, greater bed load, a higher base level (less steep gradient), and flowed less rapidly. Archaeological sediments in the RM 590 area record long wave lateral migration. Riparian environments were more extensive because of the higher water table and slower moving stream. There would have been fewer rapids because of the higher water levels and greater amount of sediment.

The following period, between 2500 B.P. and historic times, was warmer and drier with an environment generally like the modern one. Higher temperatures and less precipitation are indicated by recession of montane glaciers and a decrease in pollen influx. Sedimentary data indicate that after 2500 B.P. the Columbia River had reduced flow and a lower base level. It ceased aggradation and began downcutting again, becoming the downcutting stream observed historically. Flow was reduced in tributary streams as well, but severe flash floods were common, perhaps aided by reduced ground cover. Local erosion contributed to alluvial fan building. As water tables lowered, the size of the riparian zone decreased. The number and extent of rapids increased because of lower water levels and removal of fine sediments.

INTERPRETING PALYNOLOGICAL DATA FROM THE PROJECT AREA

It is apparent from a recent summary of palynological studies for the intermontane west (Mehringer 1985) that the amount of pollen work done on the Plateau is sufficient to allow recognition of local variability as well as abstraction of regional trends. Mehringer (1985) cautions that the traditional three-part model of Holocene climate history--a cool-moist early period, xeric middle period, and cool-moist late period--generally provides a reasonable fit for paleoenvironmental data, but is overly simplistic. He raises three issues: 1) timing and magnitude of specific vegetational events varies with elevation; 2) punctuated climatic variation reflected in fossil plant remains within major subdivisions may exceed differences between major subdivisions; and 3) at least in northern areas, vegetation assemblages of the past 2,500 years may have no early-Holocene counterparts.

The pollen sequence from Goose Lake, in the project area, is generally consistent with the regional trends outlined by Mehringer (1985). The late-glacial pollen spectra retain aspects of full-glacial vegetation and record the initial pioneering species on recently exposed ground surfaces. An initial tundra environment with some spruce and low aquatic productivity is recorded in Zone I (Nickmann and Leopold) dated around 11,500 B.P. Subalpine vegetation including birch, willow, and haploxylon pines was established between 11,500 and 10,975 (Zone II, Nickmann and Leopold). Between 10,975 and 10,160 (Zone III, Nickmann and Leopold) birch decreased while pine, including an increased proportion of diploxylon species, increased overall.

In the Intermontane west, late-glacial vegetation was replaced by Holocene vegetation by 9,000 B.P. and by 7,000 B.P. a warming and drying trend had begun that resulted in sagebrush communities expanding at the expense of grass, and both sagebrush and grass expanding at the expense of conifer communities (Mehringer 1985). In north-central Washington sagebrush-dominated steppe expanded at least 50 km northward. In the Goose Lake core these transitions occur in Zone IV (Nickmann and Leopold) dated between 10,160 and 7,800. A spectacular rise in grass pollen occurs around 9500 B.P. and pine, now dominated by diploxylon species, drops sharply. Birch and willow also decrease. In this period Artemisia pollen is about twice as common as in the modern spectra collected at 60 cm depth, and pine pollen about half as common, indicating a more steppe-like environment than modern conditions. However, the Goose Lake core records moister conditions for the 1,000 year period before Mazama ashfall (Zone V, 7,800-6,700 B.P.) an event not noted in other pollen sequences in the region (see Chapter 4 for discussion).

Regionally, the warming and drying trend had slowed by 5,400 B.P. and totally reversed by 4,000 B.P. with the return of climatic conditions resulting in more effective moisture (Mehringer 1985). In the northern Plateau, retreat of steppe is indicated by increasing conifer pollen. In the Goose Lake core, this transition is recorded in Zone III (Dalan) the lower part of which overlaps Zones V and VI (Nickmann and Leopold). Arboreal pollen is generally low, but rises steadily throughout the zone. A marked increase in pine pollen marks the boundary between Zones III and IV at 212 cm. Zone IV represents modern vegetation, and there are no late appearances of new arboreal species in the area as in other areas (Mack et al. 1978a, 1978b). The only further change in the pollen record is the late rise of Chenopodinae, thought to relate to historic overgrazing.

Problems with the chronology of the Goose Lake core make it difficult to relate the vegetation history it records directly to the archaeological record. The dates below Mazama tephra form an internally consistent sequence that corresponds well with regional vegetation trends, but the date of 9580±90 above Mazama tephra is clearly anomolous (see Table 4-1). This raises the question of whether the date of 4755±85 B.P. at 212-218 cm, critical because it dates the rather abrupt increase in effective moisture, is valid. This is a somewhat early date for the total reversal of the warming/drying trend which generally occurs closer to 4,000 B.P. However, as Nickmann and Leopold (Chapter 4) suggest in their discussion of the cool-moist period prior to Mazama ashfall, this site on the steppe-forest ecotone may be unusually sensitive to changes in the steppe-forest boundary, and the change might be picked up earlier here. Because this is a calcareous lake, there may be a problem with contamination by older carbon that could be corrected through application of a hard-water correction factor. However, this is clearly not the entire problem, or all the dates would be in sequence although too old. The history of lake chemistry, productivity, and water levels needs to be examined critically in order to determine the possible source of contamination and whether the 4755 B.P. date is likely to have been affected. Even if the 4755±85 B.P. date is valid, it should not be compared directly to the cultural sequence, which is based on dendrocorrected radiocarbon dates. Dendrocorrection would yield a date of 5400-5500 B.P.

Details of the lake history should also be worked out in order to interpret sedimentation rates and pollen influx rates. The grey clay deposit at the base of the core is the only clearly allochthonous deposition; the rest of the sediment is probably autochthonous, derived from algae and other plants growing in the lake. Algae concentrations were very low prior to Mazama ashfall, but increased rapidly in the mid-Holocene. Sedimentation rate would be highly related to climatic variation. The fastest sedimentation rate recorded in the Goose Lake core (9yr/cm), between 6,700 and 4,755 B.P., probably does not reflect an influx of inorganic sediment, but may indicate a warm shallow lake that was particularly productive for some kinds of algae. Chatters (1984c) suggests that low pollen influx rates in the Plateau after 2500 B.P. indicate low plant productivity and less effective moisture than in the preceding period. There are no dates above the 4755±85 B.P. date in the Goose Lake core, but if we assume the sedimentation rate is constant, the relatively high pollen concentrations for the upper part of Zone IV indicate high, rather than low, pollen influx.

In conclusion, the local fossil pollen record mirrors the regional record and provides important paleoenvironmental information that can be related to project area cultural prehistory. In the last 7,000 years there have been two distinct climatic periods, a warm-dry mid-Holocene period and a late-Holocene period of higher effective moisture. During the earlier period, the vegetation was open shrub-steppe, dominated by Artemisia, grasses, chenopods, and other herbaceous species. Pine and spruce increased while grass and Artemisia decreased in the later period. Because the timing of climatic events and their effect on vegetation communities varies among regions (Mehringer 1985), it would be best to use the Goose Lake core to indicate the timing of this shift in the project area. Unfortunately, the date of 4755±85 B.P. at the boundary between these two periods is of questionable validity because of the clearly anomolous underlying date. Because the chronological question cannot be resolved here, we will use the general regional dates for increased effective moisture, beginning around 5400 B.P. and culminating by 4000 B.P. Regardless of what date is used for the increase in effective moisture, there are still problems in applying this information to interpretations of cultural prehistory. First, the trend begins gradually even if it does end in a fairly abrupt shift; we do not know at what point human adaptive systems would have been affected. Secondly, we assume that climatic fluctuations within these periods could have been extreme, although brief.

INTERPRETING SEDIMENTARY SEQUENCES IN COLUMBIA RIVER SITES

A number of assumptions are involved in interpreting geomorphological history in a riverine environment, especially when relating river behavior to regional climate. These assumptions concern: 1) relationships between discharge, water level, and competency; 2) long and short-term variability in discharge levels, the seasonality of discharge, and the frequency of floods of different magnitudes; 3) channel and valley morphology and the relative importance of different depositional processes; and 4) base levels, base level changes, and isostasy. As more Holocene geomorphological reconstruction is done in the Plateau area in connection with archaeological research, these issues will require more explicit discussion.

DISCHARGE, RIVER LEVEL, AND COMPETENCY

Interactions between hydrologic parameters such as discharge, velocity, bed load, suspended load, deposition and erosion have been studied extensively by hydrologists, both empirically and experimentally. Although the relationships are well understood and can be expressed mathematically, they can be difficult to apply in paleoenvironmental reconstruction. If more than one variable changes, which is usually the case, we do not know the net effect unless we know the magnitude, not merely the direction, of change.

For example, the reconstruction of river history by Chatters (1984c) equates greater discharge with greater bed load, higher water levels, and reduced velocity. This equation is arguable. The increased flow might have been sufficient to handle the increased bed load without a drop in velocity.

For most changes in sedimentation observed in archaeological sites, there are several alternative explanations. For example, a change in deposition within a fan in the Rocky Reach area, from fluvial deposition of fine sands and silts in the lower fan unit to fan growth dominated by gravelly mud flows, could be due to a change from perennial to ephemeral fan stream flow, a change in the seasonal distribution of precipitation, a lowering of the base level of the Columbia, or all three factors (Mierendorf 1983).

SEASONAL VARIABILITY AND FLOOD PERIODICITY

Any model of how the river would be affected by regional climatic change should take into account seasonal variation in hydrologic parameters, and the season during which increased tributary flow would have occurred. Different drainage basins within the Columbia River system very greatly in terms of size, shape, stream patterns, channel storage, and precipitation patterns, and thus discharge patterns, including flood frequency (Rantz and Riggs 1949). For example, the headwaters drain high mountainous areas with numerous glaciers and snow fields, and the eastern tributaries drain timbered mountainous area. Between the Spokane and Snake River, there are no major tributaries and the annual runoff for this 9,000 sq mile area is virtually zero (Rantz and Riggs 1949). The upper portion of the Columbia River has an unusually regular high-water cycle, with high waters occurring in summer and due primarily to snow melt. Rainfall is rarely a cause of flooding, except in very localized areas on small tributaries. In their analysis of flood magnitude and frequency, Rantz and Riggs (1949) suggest that floods of the magnitude of the 1894 flood (approximately 700,000 second-feet at Kettle Falls) have a recurrence interval of between 50 and 60 years.

The annual and short-term (50 years) variation in flow is currently so great that it is possible regional climatic change would affect the timing or duration of variation in flow more than the magnitude. Empirical work estimating these parameters for the past would be useful because the historic hydrologic record for the Columbia River is not extensive, and at any rate, hydrologic parameters cannot be assumed to be constant in the past. Chatters (1984b) study of flood frequency in late Holocene deposits in the RM 590 area is an excellent example of the kind of empirical work needed.

CHANNEL AND VALLEY MORPHOLOGY

More consideration should be given to the appropriateness of particular hydrologic models to the area in which sedimentary sequences are being interpreted. The approach taken by Mierendorf (1983) is welcome in this regard; he outlines the problem of interpreting fluvial processes in a canyon-constrained river, the Rocky Reach of the Columbia River. He argues that canyon-constrained rivers behave rather differently than the classic models of braiding and meandering rivers. Rock walls and pendant bars of coarse gravelly Pleistocene outwash inhibit meandering of the channel and restrict the extent of point bar lateral accretion. Bedrock outcrops, pendant bars, and alluvial fans influence deposition also by creating eddy currents that result in longitudinal mid-channel and channel marginal bars.

Other segments of the Columbia River may not have such narrow, steep bedrock walls as the Rocky Reach, but anywhere the Holocene Columbia River is entrenched in an old channel previously occupied by a larger stream, the constraints of the canyon are a significant factor in fluvial processes. In Rufus Woods Lake, valley walls are formed of a range of materials from resistant bedrock to unconsolidated deposits of varying resistance to erosion--glacial tills, imbricated flood deposits, glaciolacustrine silts. The relative erodability would exert considerable influence on the course taken by the river. Even the relatively erodable fine glaciolacustrine sediments occupy such huge volumes that they restrict river movement. To widen the valley even a little the river must remove an incredible volume of sediment.

Landslides also influence fluvial processes in the Columbia River canyons; the degree of influence varies, but where landslides are common or large in size, they have a major impact on river history (e.g., the Cascade Landslide in the Columbia Gorge). The more rapid the downcutting of the river or the lateral movement, the more frequent the rate of sliding, which would slow the river down and perhaps cause temporary ponding and subsequent flash flooding when dams were breached. Landslides could have contributed to a long-term equilibrium in which rates of downward and lateral movement did not vary much, or they could have contributed to disequilibrium involving damming, breaching, and downcutting.

Mierendorf (1983) focuses on horizontal constraint of river activity by canyons, but the ancient channels also provide vertical constraints. Throughout much of its length, the Holocene Columbia River has downcut through glacial sediments until it reached the old bedrock channel. Even if all other factors remained equal, reaching the more resistant bedrock channel could have a drastic effect on the rate of downcutting and other aspects of Columbia River hydrology. In the Rufus Woods Lake, the channel bottom profile shows abrupt changes in gradient, probably reflecting bedrock sills cut by a rather different kind of flow, such as catastrophic floods, which now control the local gradient of the modern stream to a great extent.

BASE LEVEL CHANGES AND ISOSTATIC REBOUND

Sequences of alluvial deposition proposed for parts of the Columbia River system frequently attribute changes in the nature of river deposition to changes in base level. For example, Mierendorf (1983) suggests there were four periods of alluviation in the Rocky Reach area. The first, initiated before 8200 B.P. and continuing for an unknown duration, may be related to a lower base level than later episodes. Another period of aggradation began before 3,000 B.P., possibly at a higher than modern base level. A third period of alluvial deposition began before 1400 B.P. and terminated between 1400 and 1200 B.P. After this time the Columbia River may have been graded to a lower base level and a possible fourth alluvial episode may be represented by a terrace remnant with recent St. Helens ash. However, Mierendorf (1983) does point out the sampling problem involved; site testing was limited and it is fully expected that evidence for additional periods exists but has not been detected.

Chatters' model makes the assumption that shifts between downcutting and aggrading regimes would be synchronous throughout the Columbia River system, i.e., that different segments of the Columbia River system respond to a single base level. While the primary base level of the Columbia River system at the mouth obviously exerts influence over the entire system, in any given area the influence of a secondary base level may be of greater magnitude. Secondary base levels may be relatively independent of each other and of the primary base level. For example, in the late-glacial and early Holocene (13,000 to 9,000), sea level was rising and yet the Upper Columbia River was downcutting. Mierendorf (1984) contrasts the hydrologic histories of the Snake and Kootenai Rivers, the two largest tributaries of the Columbia River. The Snake River drainage includes limited areas of Pleistocene montane glaciation, while the Kootenai River drained both the Cordilleran ice sheet and extensive alpine glacial systems. The late-glacial adjustments of the rivers were not synchronous; between 11,000 and 10,000 B.P., the Kootenai river was still 150-200 ft above the modern river level, while the Snake River floodplain was stabilized at roughly the modern elevation.

It should be possible to model systematic differences expected in the history of different portions of the river based on factors such as distance from glacial margin, time of glacial withdrawal, type of glacial deposits, and the amount of rebound after glacial retreat. It is likely that the degree of independence of secondary base levels has changed in a predictable way through time. Throughout the Holocene the Columbia River has been removing large volumes of glacial sediments from throughout the drainage and early in this process the local base levels probably were relatively independent. Once sea level had stabilized, the effects of isostatic rebound had diminished, and the amount of glacial material was reduced, the river probably began to act more in response to a single base level. If this is true, sedimentary sequences in different parts of the Columbia River sequence should be quite different in the early Holocene and become more and more similar through time. As mentioned above, trends in base level change could be abruptly halted by reaching the bedrock channel.

Because of the effects of isostastic rebound after the retreat of glacial ice, tracing terraces by elevation alone within a limited area is problematic even within a limited area (i.e., local variations in amount of rebound) and it is certainly not possible to trace terraces between areas on the basis of elevation alone. In addition, it means terrace elevations are not directly equivalent to river levels.

INTERPRETING SEDIMENTARY SEQUENCES IN THE PROJECT AREA

Hibbert (Chapter 2) does not address the geomorphological history of the project area in the mid- and late-Holocene, but his detailed discussion of Pleistocene and early Holocene history provides a background for understanding the hydrologic and topographic conditions that obtained around 7,000 years ago. The project area lies entirely within the Columbia River canyon which is cut into Miocene and Cretaceous bedrock formations, and filled with unconsolidated sediments of Pleistocene and Holocene age. The older bedrock deposits, of interest primarily because they have constrained the movements of water and ice throughout the Quaternary, are summarized by Hibbert. The bulk of the deposits are Pleistocene in age, laid down by glacial-related events such as ice movement, lake formation, and canyon downcutting, all of which affected vast areas.

The confluence of the Omak Trench and the Columbia Valley is the boundary between two segments of the river canyon with different geologic histories. As discussed by Hibbert (Chapter 2), the upper canyon, from Grand Coulee to the Omak Trench, follows a plateau-marginal course and has granitic bedrock on the northern rim and basaltic rocks on the southern rim. The lower canyon, from the Omak Trench downriver, cuts between the Waterville Plateau and the outlying Omak Plateau, and is characterized by basalt bedrock on both rims. The late Pleistocene history of the upper and lower canyon also differ. When the Okanogan Lobe of the Cordilleran ice sheet had withdrawn to the Canadian border by 12,000-13,000 B.P., remnant ice was left in the canyons. Ice remained longer in the lower canyon, impounding meltwater to form glacial Lake Columbia in the upper canyon. A thick deposit of glaciolacustrine sediments, the Nespelem Silt, was laid down in the upper canyon. After breaching the lower ice dam, the Columbia River downcut rapidly through the lacustrine sediments, creating a deep narrow valley with a prominent terrace system which can be traced from just downriver of the mouth of the Nespelem River to beyond Grand Coulee Dam upriver. Subsequent damming by ice or a landslide caused a second lake to form in the upper canyon. The river eventually breached this barrier as well and flowed in the lower canyon again, halting at 305 m to cut extensive terraces in lake fill, flood gravels, and till. Because of multiple ice dams occurred in the vicinity of the Omak Trench, the lower canyon is characterized more by gravels of Spokane type floods, while lake sediments are more typical of the upper canyon.

During the early Holocene (10,000 to 7,000 B.P.), prior to the earliest known human occupation of the area, geologic events were still strongly influenced by earlier glacial events. According to Hibbert (Chapter 2), the Columbia River completed its dissection of the glaciolacustrine sediments filling the canyon and reached approximately its historic elevation by 7000 B.P., leaving a deep canyon characterized by a well-developed terrace system, and a narrow channel occurring entirely in bedrock.

Depositional and erosional processes responsible for altering the landscape since about 7,000 years ago include lateral migration, point bar and overbank deposition of the Columbia River, alluvial fan development, colluvial deposition and landslides, and aeolian deposition. Local lateral migrations of the channel are recorded by the shape of the river, point bars, and erosional episodes preserved in site profiles. There is little floodplain development in this narrow and incised valley but natural levees and abandoned channels can be recognized in some areas. Surfaces less than 20 m above historic river levels commonly exhibit overbank deposits of the Columbia River. Small alluvial fans have developed at the mouths of tributaries draining the steep slopes on either side of the river. There are currently few permanent drainages in the project area, most of the drainage on the slope being intermittent and unintegrated. Talus slopes are common at the base of both granitic and basaltic bedrock formations. Erosion and colluvial redeposition of the thick glaciolacustrine sediments in the upper canyon is common and may take the form of either major landslides or small deposits. A thin layer of aeolian sediments caps almost all stable surfaces.

Mid- and late-Holocene depositional agents are more localized in effect than the Late-glacial and early-Holocene depositional processes. While the frequency and importance of various depositional and erosional processes has no doubt changed throughout the Holocene in response to changes in regional climate, the geologic events which shaped the riverine landscape during the Holocene overwhelmingly have been influenced by local conditions. The riverine/canyon environment offers sufficient topographic and hydrologic variability that all the above depositional processes probably were represented within the river canyon at all times. Thus regular changes in sediments at any given site may be related to shifts in depositional environment independent of regional climate, such as lateral movement of the river channel. Nonetheless, major variations in regional climate should be reflected in changes in the intensity and frequency of the above types of depositional agencies.

The latter three of the general interpretive issues raised above are discussed in the following sections. Because the site sedimentary data was collected primarily for intra-site analysis, rather than for purposes of regional paleonvironmental reconstruction; we can examine these questions only in a very general way. A more conclusive study would require re-analysis of site sediment data emphasizing dating of geologic events, differences in sequences in different parts of the river, and estimates of deposition rates.

SEASONAL VARIABILITY AND FLOOD PERIODICITY

Historic data indicate considerable seasonal and short-term annual fluctuation in river discharge and water level. For example, at site 45-DO-211, the discharge on November 16, 1942 was 38,500 cfs, and on June 21, 1943, it was 319,100 cfs (USACE 1945). The high water level, on June 21, rose from 319,100 cfs at 45-DO-211, to 319,900 cfs at 45-DO-282, 34 miles downstream. In general, the difference between high and low water levels on 1942/43 ranged from 26 ft to 40 ft at various locations within what is now the reservoir and averaged 30 ft. The highest recorded flood peak at Grand Coulee Dam was 638,000 cfs, June 12, 1948. The 1894 flood was not recorded directly, but elevations of over 70 ft were observed at Grand Coulee Dam and the reconstructed discharge was 740,000 cfs. The same flood was approximately 700,000 cfs at Kettle Falls, where the average peak flow between 1916 and 1940 was 346,900 cfs. Floods of the magnitude of the 1894 flood probably occurred at a frequency between 50 and 60 years (Rantz and Riggs 1949).

According to Rantz and Riggs (1949) river discharge in this area is controlled primarily by snowmelt and runoff in basins draining into the Columbia River above the Spokane River. Changes in discharge volume and competency might therefore be only indirectly related to environmental changes within the local area.

Over 25 distinct flood events dating between 2000 and 0 B.P. were recorded at 45-OK-197 by the RM 590 project (Chatters 1984b). A large number of radiocarbon dates tied to this sequence allowed analysis of variation in flood periodicity during this period. Floods high enough to deposit on this surface occurred at a frequency of once per 83.65 years between 1870 B.P. and 980 B.P. Between 980 B.P. and 560 B.P., the flood frequency was once every 34 years, and since 560 B.P. they have been occurring only once every 137 years. The elevation of the surface changed from 293.5 to 295.5 m a.s.l. Denton and Karlen (1973) note a cool period between 1500 and 1000 B.P., ending just when the period of most frequent flooding begins. The latest period, when flooding is least frequent, encompasses the Little Ice Age.

CHANNEL AND VALLEY MORPHOLOGY

As Chatters (1984c) suggests, the Columbia River in the project area was no doubt a braiding channel as it rapidly downcut through glacial sediments. The gradient and discharge rate both decreased rapidly in the early Holocene as the glacial meltwater contribution ceased and the river cut lower in an increasingly narrower canyon. The river would have become less and less braided through time, gradually turning into the single channel river observed in historic times. Some of the characteristics that favor braiding still obtain, such as fluctuating discharge, heavy sediment load, steep gradient, coarse load and easily erodable banks. Meirendorf (1983) argues that the Rocky Reach of the Columbia River is still perhaps more typical of a braiding pattern than a meandering pattern, although neither model fits well. The same is true for the Rufus Woods Lake portion of the river, which is generally a single channel, low sinuosity stream. Crozier (1983) suggests the river in the project area is a meandering stream, but it does not have the high sinuosity or well developed floodplain of a classic meandering river. Neither does it fit the pattern of a braided river, characterized usually by multiple channels and ephemeral mid-channel bars. There are some channel islands (e.g., Buckley Bar), but they are cut off point bars, rather than true channel islands. Apart from the poorly developed floodplain, the depositional features are more like a meandering than a braiding stream. The low sinuosity is due to restriction of lateral movement by the entrenchment of the river in the relatively fine-grained, loose lacustrine fill and bedrock walls of the ancient canyon. In fact, this reach of the modern Columbia River is most like a straight channel, as perhaps are other reaches with deeply entrenched valleys.

Straight channel reaches are rare in streams and not expected to be very long (Leopold et al. 1964). Flow and depositional patterns are the same in straight channels as in meandering channels. Like meandering channels, straight channels shift their position by lateral accretion. Erosion takes place in pools and deposition on point bars. There are riffles at the crossovers between bends. The same three kinds of fluvial deposits occur in straight channel stream as other kinds of channels: channel, bank, and flood basin deposits.

Channel deposits include channel lag, channel bed, channel fill, and bar deposits. Channel deposits are primarily bed load material but may include some suspended load material. Sediment accumulations in channels which form topographic highs are called bars. Meandering and straight rivers are characterized by point bars. These differ from the channel bars in braided rivers, which migrate actively. Point bar sediments are the coarsest carried by the river next to channel lag deposits.

Point bars are a function of the flow characteristics of the channel. The maximum flow velocities are near the steep concave bank just downstream from the axis of a bend. The river erodes its bank in this area, and deposits material on the convex bank, where velocities are at their minimum. The material eroded from the concave side tends to be deposited on the point bar of the next downstream meander, not on the point bar on the opposite convex side. Deposition on point bars is rapid and much of it takes place during floods.

Both bank and floodbasin deposits are primarily suspended load sediments. Bank deposits are sediments deposited on the river bank during flood periods--levee deposits and crevasse splay deposits. Flood basin deposits are fine-grained sediments left during heavy floods when water flows over levees.

In the project area we find typical sequences of channel lag deposits overlain by point bar, bank, and overbank deposits. The Columbia River gravels (Qcr) which cover terraces at all elevations are channel lag deposits. They are clast-supported deposits of very coarse material. At many of the archaeological sites, the coarse gravel and cobble deposits are covered by finer materials that represent point bar deposition. The bank deposits and floodbasin deposits that overlie point bar deposits at many of the sites are not well differentiated, a characteristic of poorly developed flood plains. The poor development of the floodplain is apparent simply from the topography--cases of topographic highs indicating levees and lows indicating backwater basins are rare. Poor floodplain development commonly is associated with rivers that actively migrate laterally, but in the case of the Columbia River in the project area may be due to the nearly continuous downcutting of the river and to its entrenchment in a deep, inherited valley rather than to active lateral migration. Although we recognize levee development in a few areas on the basis of topography, we could not reliably distinguish levee deposits from overbank deposits in site profiles. Extremely fine-grained slackwater deposits also are infrequent.

A number of problems were encountered in identifying types of landforms and deposits. Because of lack of extensive field information on the three-dimensional shape and bedding characteristics of the deposits, it was necessary to rely on relatively rough criteria. This has no doubt led to some misidentifications, especially in this setting where many of the expected deposits are difficult to distinguish. Reineck and Singh (1973) mention the difficulty of distinguishing aeolian reworked material from alluvial material on upper bars, the difficulty of telling bank and flood basin deposits apart in a poorly developed flood plains, and the difficulty of distinguishing overbank deposits, especially levee deposits, from upper bar deposits.

Because the history and morphology of the upper and lower canyons are different, we expect the depositional environments and processes to be somewhat different, at least in frequency. Terraces are not as well developed in the lower valley and the walls are steeper and narrower. The difference between high and low water surface elevations was probably greater in the lower part of the canyon because of its narrowness. Today, the difference in the canyons is highlighted by the reservoir; Rufus Woods Lake is not considerably wider in the lower canyon even though the depth is greater.

BASE LEVEL CHANGES AND ISOSTATIC REBOUND

While the Rufus Woods Lake area could not have been totally unaffected by changes in base level downstream, its relationship to local base levels was probably more important. The amount of glacial sediment in this area, and the late cessation of glacial influence may mean that this area was responding to a local base level until well into the Holocene.

As Hibbert (Chapter 2) discusses, the river began downcutting from the base of lake sediments at 520 m sometime after 13,000 B.P., and reached 380 m (1235') at either 12,600 or 11,200-11,300, and reached 310 m (1000') by 6,700

B.P. He argues that as the river had reached the 1000' elevation sometime prior to 7000 B.P. it probably reached historic elevations shortly thereafter. Because a large number of archaeological sites in the project area are found on landforms below the 1000' terrace mentioned by Hibbert, a finer resolution of chronology is desirable. Although the time elapsed may have been "short" in geologic terms, a difference of 20 meters or 1000 years would be significant in archaeological terms. This issue is discussed in more detail following presentation of the site sedimentary sequences.

The lowest strongly expressed terrace in the project area (Hibbert, Chapter 2) is the one found at 1100' at Grand Coulee Dam, grading to 1000' at the mouth of the Omak Trench, yet lower to Allen Bar and Gaviota Bend, and not well expressed further downriver. There are both erosional terraces and aggradational bars below this terrace. It is difficult to trace these recent terraces the length of the reservoir. In some areas, landslides and colluvial deposition have destroyed or obscured terrace remnants. Terraces are not as prominently expressed in the coarse till deposits of the lower canyon as in the glaciolacustrine sediments of the upper canyon. We used the 1100-1000' terrace as a reference point in tracing lower, less prominent terraces. It is the T3 terrace in the RM 590 reach and is around 1050' in elevation between 45-OK-2 and 45-OK-250. Table 5-1 presents the approximate elevation range of terraces by reach. These are only preliminary; they are based on inspection of topographic maps and were not field checked.

Table 5-1. Terrace elevations by reach.

Terrace	RM 590-585	RM 585-575	RM 575-565[2]	RM 565-555[3]
T_0	940-965	915-945	865-915	850-900
		Nespelem Bar 903-942	bar below Parsons Rapids	
		890-925 at RM 575		
T_1	965-1000	945-980	915-950	900-925
T_2	1000-1050	980-1025	950-1000	925-950
			DO side at RM 569 OK side at RM 566 with alluv. fan	
T_3	1050-1090	1025-1050	1000-1050	960-1000
			see DO side at RM 568-567, OK side at RM 571	Allen Bar, Gaviota Bend, OK side at RM 563
T_4	1100-1150	1050-1100		1000-1050
				DO side at RM 557 gradual gravel covered slopes at RM 553, DO side

1. Elevations from USGS 15' quadrangle maps and USACE (1945) (river before impoundment).

2. The T3 in reach 575-565 and 565-555 may or may not be cogenetic with the T4 above the Omak Trench. All terraces in the lower two reaches may differ in age from those in the upper canyon.

3. Contours below 900' were not mapped below RM 566 on USACE (1945)

SEDIMENTARY SEQUENCES BY REACH

Location and elevation relative to the Columbia River is summarized for the excavated sites in Table 5-2. Individual site sequences are discussed below, arranged by reach.

Table 5-2. Site locations and elevations.

Site	Elevation		Terrace	River Mile	River Elevations 1942/43[1]		
	M	FT			Average Bottom	Low Surface	High Surface
RM 590-588							
45-DO-211	298	977	T1	590	913	929	955
45-DO-214	293	961	T0	589.5	910	927	954
45-DO-285	291	954	T0	588	922	924	952
RM 581-579							
45-OK-2A	291-294	954-964	T1	581	890	902	932
45-OK-2	290-293	951-961	T1	580.5	891	900	931
45-DO-242	290	951		579	885	898	928
45-DO-243	292	958		579	885	898	929
RM 578-575							
45-OK-4	290-293	951-961	T1	578	880	897	927
45-OK-250	290-295	951-968	T1	578	885	897	927
45-OK-258	290	951	T1	576	886	895	925
45-OK-11	291	954	T1	575	883	893	924
RM 568-567							
45-OK-287/288	289-291	948-954		568	845	874	902
45-DO-204	292	958	T3	567	830	874	900
RM 561-556							
45-DO-273	290	951	T2	561	825	850	885
45-OK-18	293	961	T3	561	825	850	885
45-DO-326	290	951	T2	558	818	845	880
45-DO-282	289-295	948-968	T3	556	794	825	865

1. Taken from USACE (1945). High surface (approx. 319,000 cfs) was measured on June 21, low surface (38,000 to 52,000 cfs) measured in October and November.

RM 590-588

The three furthest upriver sites, 45-DO-211, 45-DO-214, and 45-DO-285, lie between RM 590 and 588. Sediment sequences from these sites are summarized in Figure 5-1. Additional data on sediments from archaeological sites in this reach can be found in Chatters 1984a and 1984c.

```
Years       45-DO-211                 45-DO-214                   45-DO-285
 B.P.         (T1)                       (T0)                        (T0)

  0                              hist. flood deposits         hist. flood deposits
                                                             *
          aeolian reworking      buried vegetation mat       *upper overbank deposit
          of sediments,          some soil development       - - - - - - - - - - - -
1000      only intermittent      * - -?- - -?- - -?- - -
          overbank deposition    *1 m overbank deposit        middle overbank deposit
                                                             - - - - - - - - - - - -
          soil development              hiatus?              Lower overbank deposit
2000                             - - -?- - -?- - -?- - -          bar cut off
          surface stabilizes                                 - - - - - - - - - - - -
         - - - - - - - - - - - -
         *                       colluvial deposition,        point bar formation
3000     *  rapid overbank              erosion              - - - - - - - - - - - -
         *    deposition
         *
         *
4000       3 strata seperated    - - - - - - - - - - - -
           by surfaces, upward
           increase in grain
           size, thickness of
5000       beds

         * - - - - - - - - - - -

6000      point bar formation


7000


8000
 * indicates radiocarbon date or dates.
```

Figure 5-1. Sequence of deposits at sites between RM 590 and 588.

We suggest a revision of the terrace sequence proposed by Chatters for this area. First, the lowest surface, T0 or the historic floodplain has a greater vertical extent. The surface elevations of Buckley Bar, indicated on a pre-reservoir map, are 920.1-966.8. Low water elevations in 1942/43 in this vicinity ranged from 924 to 929 ft, and high water elevations from 952-955. The lower boundary of the floodplain should be lower than the elevation of the annual flood stage, but not as low as the lowest water level, which probably exposed channel deposits. The next lowest terrace, T1, is between 960 and 1000' in elevation. Chatters (1984c) terms this terrace, Sanderson Creek Bar, an aggradation terrace, but it actually is the lowest erosional terrace, as indicated by the Nespelem silt exposed in the bank at the downstream end of Sanderson Creek Bar. There are aggradational floodplain deposits on the terrace surface, however. The terrace across from 45-DO-214, T2, lies between 1000 and 1050'. The terrace across from 45-DO-211, the T3 terrace, is above the 1050' contour. The T4 is above the 1100' contour.

Sometime before 5500 B.P. the river had dropped from the 1050' level to the 1000' level and was forming the point bar on which 45-DO-211 is located. The Columbia River flowed across the bar until sometime shortly before 5500 B.P. A series of interbedded, highly variable, but well sorted sediments represent a point bar deposit on top of the channel lag deposit. The point bar was seasonally exposed and attractive for human use around 5500 B.P. A probable hearth remnant, dated at 5497±142, was found on a stratum of coarse sand directly overlying the cobbles. The hearth is better preserved than other early deposits associated with point bars, suggesting that overbank deposition began soon after 5500 B.P. As the channel migrated laterally to the north, overbank deposition began. The next evidence of occupation of the bar, nearly 2000 years later, is a housepit with dates of 3505±74 and 3636±100. By this time, sufficient overbank deposits had been deposited on the bar to allow excavation of pit houses into the sediments.

Between 4,000 and 2,000 B.P. overbank deposits were being laid down regularly at 45-DO-211 and colluvial deposits formed at 45-DO-214. The river during this period was building the point bar across from 45-DO-214 and eroding the left bank of the river at 45-DO-214. Vertical accretion of overbank deposits on the 45-DO-211 bar continued.

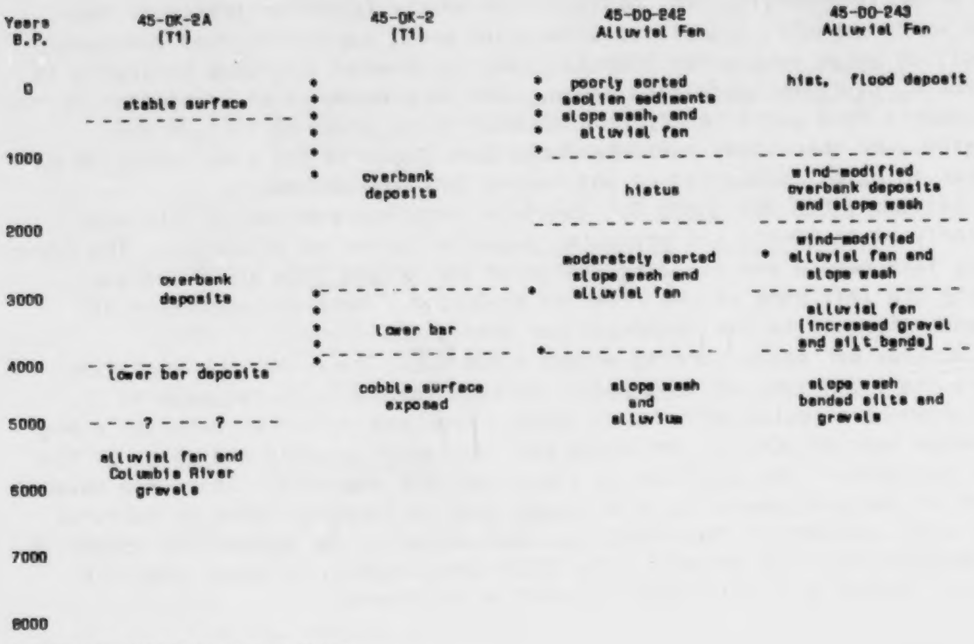
Buckley Bar began forming around 3,000 B.P. The river was migrating toward the right bank at that point, perhaps partially in response to deposition of alluvial material by Moses Creek and colluvial material along the slope near 45-DO-214. At 45-DO-285, the basal gravels and sands of the lower bar deposit are overlain by finer overbank deposits. There are several strata of overbank deposits, with associated radiocarbon dates on cultural materials; 1680±950 in the oldest overbank deposit, and 299±90 and 350±80 in the youngest overbank stratum. The 1948 flood deposit is found near the surface, capped by a thin layer of aeolian sediments.

RM 581-579

Sites 45-OK-2, 45-OK-2A, 45-DO-242 and 45-DO-243 lie between RM 581 and 579. Sedimentary sequences from these sites are summarized in Figure 5-2.

Sites 45-OK-2 and 45-OK-2A are on a large point bar on the north side of the river just downstream from the tip of Nespelem Bar. The bar abuts granite bedrock slopes, and the internal margin slopes steeply because of colluvial contribution. The front margin of the terrace is a wide, gently sloping surface with evidence of floodplain development, i.e., a linear topographic rise that is apparently a levee, and an adjacent linear topographic low that is a backwater channel. The river evidently cut as far as the granitic bedrock and then began to reverse direction. As it began to migrate south it built the lateral bar behind it. The bar was built over a period of time and the deposits are progressively younger downstream. The two sites have virtually identical sequences of deposits from lower bar deposits through overbank deposits, but the deposits at 45-OK-2A are in each case older than similar deposits at 45-OK-2. The upstream end of the bar, where 45-OK-2A is found, has been built up to a slightly higher elevation, and the surface stabilized here by at least 500 B.P., while 45-OK-2 continued to receive at least occasional inundation through historic times.

Sites 45-DO-242 and 45-DO-243 are adjacent sites downstream and across the river from 45-OK-2. Both sites are on river cut terraces obscured by alluvial fan deposition. The basal deposit at each site, a Columbia River gravel bar deposit, is overlain by an alluvial fan deposit. Each fan had separate sources and a different depositional regime. Fan deposition was


Years B.P.
45-OK-2A (T1)
45-OK-2 (T1)
45-DO-242 Alluvial Fan
45-DO-243 Alluvial Fan
0
1000
2000
3000
4000
5000
6000
7000
8000
stable surface
overbank deposits
lower bar deposits
? ?
alluvial fan and Columbia River gravels
overbank deposits
lower bar
cobble surface exposed
poorly sorted aeolian sediments slope wash, and alluvial fan
hiatus
moderately sorted slope wash and alluvial fan
slope wash and alluvium
hist. flood deposit
wind-modified overbank deposits and slope wash
wind-modified alluvial fan and slope wash
alluvial fan [increased gravel and silt bands]
slope wash banded silts and gravels

* indicates radiocarbon date or dates.

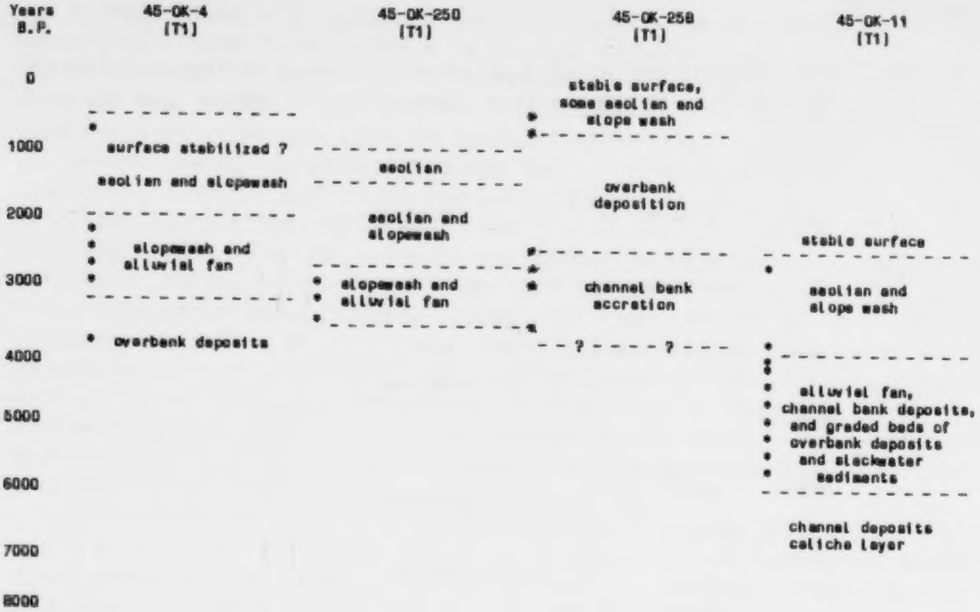
Figure 5-2. Sequence of deposits at sites between RM 581 and 579.

more rapid at 45-DO-242, where the volume of runoff and stream competence was apparently greater. Some strata are probably mudslides rather than alluvial deposits. At 45-DO-243, multiple branching channels formed a distributary network that had less competence than the 45-DO-242 stream. Individual beds are thinner and less continuous than at 45-DO-242. Alluvial fan deposition ceased around 2000 B.P. and minor amounts of slope wash and aeolian deposition characterize the subsequent period.

RM 578-575

Sites 45-OK-4, 45-OK-250, 45-OK-258 and 45-OK-11 all within the stretch of river from RM 578 to RM 575. Sedimentary sequences from these sites are summarized in Figure 5-3.

Sites 45-OK-250 and 45-OK-4 are on a low terrace at a concave meander bend of the river. This terrace, cut by the Columbia River, has been significantly modified by alluvial fan debris. A network of draws deposited material in individual fans that coalesced, forming an alluvial apron. Sterile alluvial gravels, alluvial fan, and colluvial deposits are the basal deposits at the two sites. A caliche layer has formed on some of the alluvial deposited surfaces. Vertical accretion of overbank deposits and associated thin bands of fine-grained slackwater sediments began before 4000 B.P. Iron staining indicates fluctuating water table levels. Gradually Columbia River


Years B.P.
45-OK-4 (T1)
45-OK-250 (T1)
45-OK-258 (T1)
45-OK-11 (T1)
0
1000
2000
3000
4000
5000
6000
7000
8000
surface stabilized ?
aeolian and slopewash
slopewash and alluvial fan
overbank deposits
aeolian
aeolian and slopewash
slopewash and alluvial fan
stable surface, some aeolian and slope wash
overbank deposition
channel bank accretion
? ?
stable surface
aeolian and slope wash
alluvial fan, channel bank deposits, and graded beds of overbank deposits and slackwater sediments
channel deposits caliche layer

* indicates radiocarbon date or dates.

Figure 5-3. Sequence of deposits at sites between RM 578 and 575.

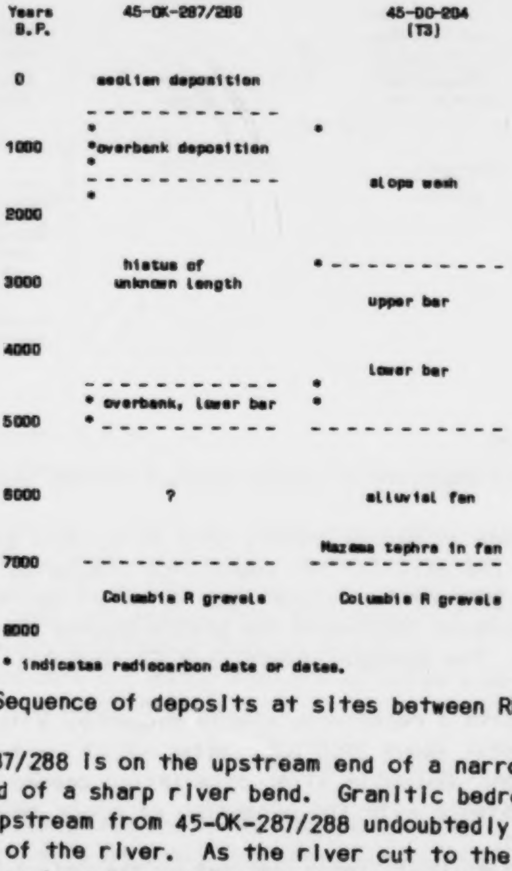
alluvial deposition ceased, at approximately 3500 at 45-OK-4 and 3000 B.P. at 45-OK-250, and slopewash and alluvial fan deposition dominated. By around 3500 B.P. at 45-OK-4 and 2000 B.P. at 45-OK-250, alluvial fan deposition had become negligible and the upper sediments are predominantly aeolian with some slope wash contribution. The surfaces stabilized at 1000 B.P. at 45-OK-4 and 500 B.P. at 45-OK-250.

Site 45-OK-258 exhibits a relatively simple sequence, with channel bank deposits predominating until about 2500 B.P., after which vertical accretion of overbank deposits began. Columbia River alluviation ceased by at least 500 B.P. and the surface was stable with the exception of minor amounts of aeolian and slope wash deposition.

The terrace on which 45-OK-11 rests was cut by the Columbia River in coarse glacial drift. As the river migrated across the terrace, it left channel bed deposits in some areas of the site. Some time after this, a caliche horizon was formed in the relatively impermeable glacial drift. From at least 6000 to 4000 B.P., the river periodically submerged the terrace, leaving a series of graded beds of overbank sediments and at least four slackwater bands. Channel bank deposits accumulated as the Columbia River migrated away from the site. These accumulated at the same time that alluvial fan debris from Hopkins Canyon and smaller ephemeral streams was being deposited. After 4000 B.P. sediment accumulation consisted of aeolian deposits and slope wash debris.

RM 568-567

Two sites, 45-OK-287/288 and 45-DO-204, were excavated in the vicinity of the Omak Trench. Sedimentary sequences from these sites is summarized in Figure 5-4.


Years B.P.
45-OK-287/288
45-DO-204 (T3)
0
1000
2000
3000
4000
5000
6000
7000
8000
aeolian deposition
overbank deposition
hiatus of unknown length
overbank, lower bar
?
Columbia R gravels
slope wash
upper bar
lower bar
alluvial fan
Mazama tephra in fan
Columbia R gravels

* indicates radiocarbon date or dates.

Figure 5-4. Sequence of deposits at sites between RM 568 and 567.

Site 45-OK-287/288 is on the upstream end of a narrow, sloping terrace at the downstream end of a sharp river bend. Granitic bedrock outcropping at river level just upstream from 45-OK-287/288 undoubtedly influenced the direction of flow of the river. As the river cut to the north, it uncovered the bedrock, and may have been deflected to the south, leaving the site area in the lee of the outcrop. Sometime before 7000 years ago, the Columbia River cut the terrace on which 45-OK-287/288 occurs and withdrew, leaving behind typical channel bottom deposits, or Columbia River gravels. These are overlain by lower bar deposits, stratified dipping deposits of coarse, waterworn materials and laminated sands and silts. Human use of the gravel bar surface began sometime before 4800 B.P. as indicated by the stylistically estimated age of the cultural materials associated with lower bar deposits. Two radiocarbon dates indicate occupation between 4800 and 4400 B.P.

After a hiatus of unknown length, this deposit was overlain by an upper bar deposit mixed with colluvium in some areas. The length of the hiatus is uncertain. There is no evidence of surface exposure, such as soil development or weathering. The dates must be considered maximum bracketing dates--the interval was probably much shorter. Increased erosion during this episode may have resulted in redeposition of cultural materials.

Human use of the site and the pattern of gradual accumulation of alluvium resumed by 1500 B.P. Alluvial fan deposition in the draw increased, but it is not known whether this is due to local or regional changes in precipitation and river level. Further alluvial sedimentation began to cover the colluvial gravels at the north end of the site with massively bedded overbank deposits. Five radiocarbon dates indicate a time span from 1500 to 850 B.P. Ephemeral streams were active at this time; there is much evidence of erosion and deposition by small channels. An overlying overbank deposit is associated cultural materials dated between 850-400 B.P. Use of the sites seems to have virtually ceased after 400 B.P. Sedimentation continued, capping the site deposits with aeolian sediments, and perhaps one flood deposit, while an alluvial fan continued building in the draw.

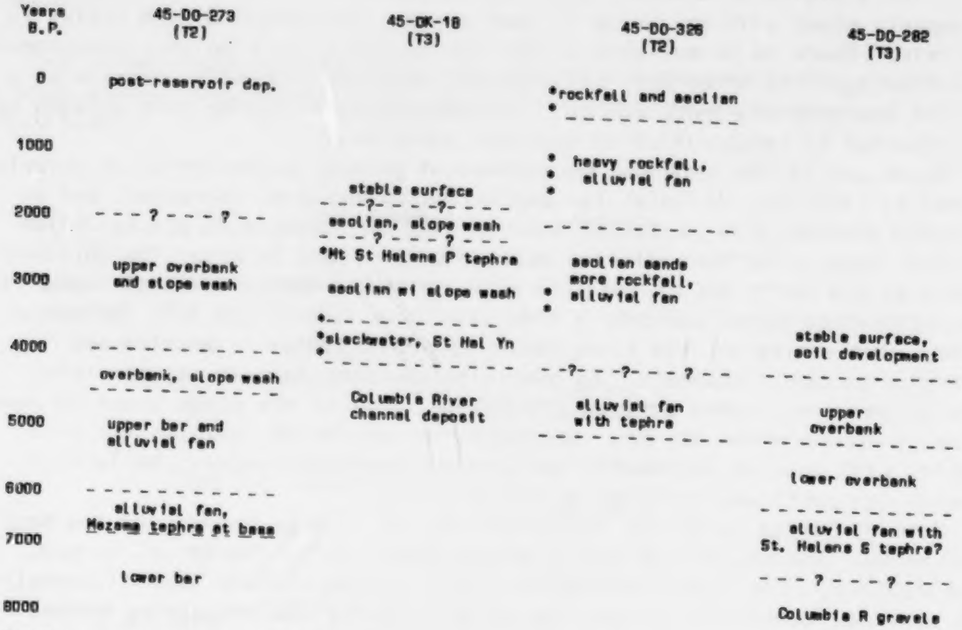
Site 45-DO-204 is at the downstream end of a large terrace, on the bank of a ravine. The ravine represents entrenchment of the fan by its stream, since 2800 B.P. The oldest sedimentary unit, Columbia River channel deposits more than 7000 years old, is overlain by an alluvial fan containing Mazama tephra. Lower bar deposits lie to the riverward side of the fan, and partially overlie it; they contain a sparse deposit of cultural materials associated with radicarbon dates of 4395±106 and 4590±143. The upper bar deposits contain the densest cultural occupation, with an accompanying radiocarbon date of 2812±334. The date, from a feature, probably dates the upper surface of the upper bar deposits. The overlying slope wash deposits contain sparse cultural materials with a radiocarbon date of 655±67. The fan deposit was interpreted as such because of the variability within the sediments, the relatively thin beds, and the fact that they were thickest away from the river. The upper bar deposits are more massive and less variable in texture than the lower bar deposits.

The start of overbank deposition at the site after 5000 B.P. indicates either general increase in effective precipitation and river load, or that the river bed had fallen below the 305 m terrace. Around 2800 B.P., the overbank deposition ceased. A cultural occupation on this surface is recorded in Zone 2. Since that time only slope wash and aeolian activity have contributed sediments to the site.

RM 565-555

Depositional sequences at sites 45-DO-273, 45-OK-18, 45-DO-326, and 45-DO-282, which lie between RM 561 and 556, are shown in Figure 5-5.

Site 45-DO-273 lies between two deep drainage channels at the river margin of a small alluvial fan at the downstream end of a 1000 ft terrace (Allen Bar). The terrace is cut into glaciolacustrine sediments and the


Years B.P.
45-DO-273 (T2)
45-OK-18 (T3)
45-DO-326 (T2)
45-DO-282 (T3)
0
1000
2000
3000
4000
5000
6000
7000
8000
post-reservoir dep.
upper overbank and slope wash
overbank, slope wash
upper bar and alluvial fan
alluvial fan, Mazama tephra at base
lower bar
stable surface
aeolian, slope wash
*Mt St Helens P tephra
aeolian w/ slope wash
*slackwater, St Hel Yn
Columbia River channel deposit
*rockfall and aeolian
heavy rockfall, alluvial fan
aeolian sands more rockfall, alluvial fan
alluvial fan with tephra
stable surface, soil development
upper overbank
lower overbank
alluvial fan with St. Helens S tephra?
Columbia R gravels

* indicates radiocarbon date or dates.

Figure 5-5. Sequence of deposits at sites between RM 561 and 566.

upstream portion is capped by channel deposits of the Columbia River. Above the 1000 ft contour is a steeper slope, of colluvial deposits, and cliffs of gneissic granite rise above the 1050 or 1100 ft contour. Lower bar deposits consisting of steeply dipping, well stratified, texturally variable sediments were exposed at the base of the site. They are overlain by an alluvial fan with a thick lens of Mazama tephra at the base. Above this are two sequences of alluvial deposition, separated by an unconformity dated around 4500 B.P. by artifacts associated with the lower deposit. The date of 1500 to 1000 B.P. given to the upper deposit is based on a a single projectile point and is not necessarily reliable.

At 45-OK-18, nearly directly across the river from 45-DO-273, the oldest deposit is a layer of coarse material with a steeply sloping surface, consisting of cobbles, pebbles, and sand, grading to medium-sized sand towards the river. This has been interpreted as channel deposits left by the Columbia River as it migrated across the bar during early postglacial times.

Above the channel deposits are very fine, horizontally bedded deposits that are unusually high in silt and clay for the project area. The fine texture of these deposits indicates they were laid down in still water and mottling in the lowest unit suggests postdepositional alteration below the water table. Freshwater snail shells are common throughout the deposit. The appropriate depositional environment may have been provided by a backwater slough on the Columbia River floodplain or by temporary ponding of the Columbia River by a landslide. Volcanic tephra is found in varying amounts in the upper part of the deposit. The largest deposits are two lenses approximately 60 cm long and 10 cm thick within a 2 x 2 m square. A sample from one of these lenses was identified by Davis as Mt. St. Helens Yn, dated around 3400 B.P. (see Davis, Appendix B). A radiocarbon date of 3780±175 within this unit, the age of the tephra, and a date of 3363±394 in the overlying unit suggest that the slackwater deposits were laid down between 3800 and 3400 B.P.

Two loamy sand deposits of mixed aeolian and slope wash origin complete the site sequence. The lower of the two is a soft, well-sorted, deposit of very fine sand and silt. Gravel inclusions increase away from the river; they apparently washed in from the slopes above the site. Small pockets of tephra and sand occur at the upper surface of this deposit. The tephra has been identified as St. Helens P tephra, dated around 2500 B.P. The youngest depositional unit also consists of aeolian and slopewash material but is darker and more compact, suggesting it has been affected by soil development. The surface was probably relatively stable and received little deposition after 2500 B.P., allowing soil development to proceed.

Site 45-DO-326 is on the 950 ft terrace directly upstream from White Cap Rapids. The three basalt erratics that form the shelter rest on a substrate of massive, glacially deposited basalt column fragments and rounded granitic boulders similar to those exposed on the point to the north. The glacial till deposit is overlain by an alluvial fan laid down by a small stream immediately to the southwest. Inside the shelter, the fan sediments are coarse sands and gravels near the western entrance, grading into finer sands toward the east, indicating deposition by a stream directly southwest of the site. Outside the shelter the fan debris is slightly coarser and mixed with more rapidly deposited mud flow material. The fan contains cultural materials dated between 5-4000 B.P. A discontinuous stratum of apparently redeposited tephra that has not been identified (see Appendix B) was laid down near the top of this unit. Alluvial fan deposition continued for a while but aeolian deposition increased in importance in the overlying units. The next deposit comprises alluvial fan materials and rockfall from the erratics. Radiocarbon dates and cultural materials indicate two occupations within this deposit, dated between 4000-2000 B.P. and 2000 to 300 B.P. The youngest deposit, rockfall and aeolian sediments, is associated with cultural materials and radiocarbon dates of 283±75 and 108±61.

Site 45-DO-282 is the furthest downriver of all project sites. On either side of 45-DO-282 are outcrops of granitic bedrock. The site is on a terrace that slopes gently from 1,000 ft down to the bank at 950 ft. Although no regional formation is mapped for this terrace, it presumably was cut by the Columbia River. The two granite outcrops at each end of the site would have affected the currents, and thus deposition, in the site area. The oldest depositional unit exposed at the site consists of rounded river cobbles, undoubtedly Columbia River gravels. Above this is an alluvial fan with a secondary tephra deposit, tentatively, but not positively identified as St.

Helens S-set, dated around 13,000 years B.P. (see Davis, Appendix B). The ash was found at the upper surface of the fan in a single unit in the southwest part of Area A. Cultural materials within the fan are estimated to be 6-7,000 years old by diagnostic projectile point styles. One of the four Cold Springs side-notched points from this cultural assemblage was found in the same level as the tephra. Above this are two massive, horizontally bedded, moderately well sorted deposits which were interpreted as overbank deposits, although the possibility that they are loess remains. Cultural materials in the lower deposit are dated at 6-5000 B.P. and in the upper 5-4,000 B.P. Cultural occupation and sedimentation stopped by 4,000 B.P. and soil development took place on the stable surface.

DISCUSSION

The site sedimentary sequences discussed above indicate considerable local variability in sedimentation due to lateral river movement and vertical aggradation of the floodplain that may overwhelm evidence for regional climate-controlled changes.

Volcanic tephras were not found to be of much help in defining or dating an alluvial sequence. The lowest elevation of Mazama tephra deposits found in excavated sites is at 45-DO-204, 58 ft above pre-dam high water levels. The 45-DO-204 tephra deposit is in a sandy alluvial fan adjacent to Columbia River alluvial deposits, indicating that the fan may have been partially subaqueous or at least that the base level of the fan (the river) was at this elevation. Other Mazama ash deposits (DO-273, +66 ft) or cultural deposits predating 6,700 B.P. (DO-282, +83 ft) are higher in elevation. Elevations of Mt. St. Helens P (2500 B.P.) and St. Helens Yn (3400 B.P.) do not aid in dating river levels because they were found only at 45-OK-18, at an elevation of +76 ft, higher than some landforms with deposits of Mazama tephra.

Therefore, we turned to dated cultural occupations as a means of dating river activity at different elevations. Because the river fluctuated 30-50 ft throughout the year, and people made use of both high and low elevation landforms at different times of the year, comparisons should be made only among similar site types on similar landforms. For example, we assume that pithouses were constructed only in areas above the local water table and that were generally dry all year. Therefore the date of the oldest pithouse on a particular landform should provide a minimum date of when the river dropped too low to regularly inundate the site. This information is not comparable to dates of cultural activity associated with point bar surfaces or other regularly inundated landforms. For example, the oldest component at 45-DO-214, which consists of unstructured dumps of rock and shell may have been in a zone that was only exposed for a short time each year.

Table 5-3 gives dates of bar formation and vertical accretion at sites arranged by elevation. If Chatters' (1984c) model is correct, we should see evidence of substantial aggradation during the mid-Holocene period (time of raised base level) and minimal aggradation before 4700-4000 B.P. and after 2500 B.P. While changes in the rate of aggradation cannot be ruled out on the

Table 5-3. Bar formation and overbank deposition through time.

Site	Elevation Above 1942/43 High Water	Oldest Pithouse Date Y.B.P.	Date of Point Bar Use Y.B.P.	Dates of Vertical Accretion Y.B.P.	Approximate Dates of Point Bar Formation Y.B.P.
45-DO-285	2	-		2200-0	3000-2200
45-DO-214	7	-		1200-0	
45-OK-2	20	>1300	4000	2800-0	4000-2800
45-DO-211	22	3600	5500	5500-3500	>6000-5500
45-OK-2A	22	?		4000-500	
45-DO-242	22	3900		1500-0	
45-OK-4	24			>4000-3200	
45-OK-250	24	3500		>4000-3500	
45-OK-258	26	2900		2500-500	4000-2500
45-DO-243	29				
45-OK-11	30	5200		6000-4000	>6000
45-OK-287/ 288	46		4800	5000-4500	>6000-5000
45-DO-204	58			4000-2800	5000-4000
45-DO-273	66		4600	4000-3000	>6700
45-DO-326	71				
45-OK-18	76				
45-DO-282	83			6000-4000	

basis of the data presented here, the overall picture presented is one of continuous lateral migration and vertical accretion in the Columbia River floodplain throughout the Holocene. Although the data are not good enough to allow us to estimate rates of accretion, our overall impression is that the rates varied at least as much between areas as through time.

Examined at a qualitative level, the project data do not support Chatters' contention that floodplain aggradation was negligible between 6700 and 4700 B.P. During this period thick overbank deposits were laid down at 45-OK-11 and 45-DO-211. He also suggests the Columbia River reached the base of the lacustrine sediments at an elevation at or below the historic bed level some time in the early or mid-Holocene; a final pre-modern aggradational terrace was formed at this time (Chatters 1984c:11). Aggradation ended sometime after 2800 B.P. when the river became oriented to a lower base level and there was little floodplain development aside fom inter-fan terraces, low point bars, and the deposition of a few historic flood deposits atop the mid-Holocene terrace. Chatters' suggestion of a pre-modern aggradational terrace may be related to his identification of the Sanderson Creek bar as aggradational; as discussed above, it is actually an erosional terrace with point bar and overbank deposits on it. Therefore, while there is mid-Holocene aggradation, there is no exclusively aggradational mid-Holocene terrace. Aggradational landforms such as Buckley Bar, a cutoff point bar, were still forming after 3000 B.P.

Point bars formed in different locations throughout the time span of the project data, beginning before 6700 B.P. The sequence shown in Table 5-3 ends at 2200 B.P., but this is an artificial truncation due to inundation of more recent point bars by reservoir impoundment. Point bar deposits at lower elevations than Buckley Bar are evident on pre-reservoir maps, indicating that point bar formation continued up into historic times. The general trend toward decreasing elevation of point bar surfaces through time indicates gradual downcutting. Vertical accretion deposits on the land forms investigated by the project begin at a slightly later date, 6000 B.P., and occur at different locations throughout the remainder of the Holocene. The lengthy time periods for vertical accretion indicate that the Columbia River at least occasionally deposited materials on floodplain surfaces as high as 20 ft above average high water levels. Presumably in most locations, most of the overbank deposits were deposited within a relatively short period of time, after which the frequency and thickness of depositional events decreased rapidly.

The gradual decrease in elevation of both point bar formation and vertical accretion suggests the river was downcutting, although at a relatively slow rate. A model of the river as vertically stable, or slowly but continuously downcutting should be considered as a heuristic alternative to models invoking considerable changes in base level. However, this is not to imply that the project data consistently support such a model; in fact, there are several problems with this interpretation. First, we have only looked at river activity in a qualitative way and have not examined rates of aggradation. Secondly, even at the qualitative level we do not have close bracketing dates on most geologic events. Emphasis was placed on dating cultural events/cultural episodes (in both date selection and subsequent analysis). If more precise dating was done, aggradation might be seen to be more episodic. Third, several site sedimentary sequences show changes in depositional environment that suggest rising river levels. For example, the occurrence of lower bar sediments at 45-DO-204 that abut and overlie alluvial fan sediments containing Mazama tephra may indicate rising river levels some time after 6700 B.P. unless the fan was at least seasonally subaqueous. Lateral accretion overlying overbank deposits at 45-OK-11 suggests a rise in river levels. Hiatuses or unconformities at 45-OK-287/288 and 45-DO-273 between 4500 and 1500 B.P. may indicate interruption and later resumption of Columbia River deposition. These changes in depositional regime should be analyzed further to determine if they have local causes. Fourth, even if the river was generally downcutting since about 7000 B.P., it is highly likely there were short-term reversals. Depending on their duration and magnitude we might observe the effects of reversals in the sedimentary record, even if they were not a long-term, regional trend.

Chatters suggests a period of soil formation, when it was cooler and moister, between 4000 and 5000 B.P., resulting in buried soils consisting of calcium and silica rich B-horizons. The caliche layers at 45-OK-11 and 45-OK-250 seem more likely to have been formed during an arid period. Soil development also occurred after 4000 B.P. at 45-DO-282 and after 2500 B.P. at 45-OK-18. These cases seem more likely to reflect the long period of time that the surfaces were stable, and not the climatic conditions at the time they stabilized.

We cannot independently test the assertion that loess formed on the T2 and T3 terraces from before 6700 B.P. until 4700 B.P. No substantial deposits were identified as loess, but given the difficulty in distinguishing wind-reworked alluvial material from aeolian deposits, this may be an error of identification. The massive, horizontally bedded deposits at 45-DO-282, 45-DO-204, and 45-OK-18 in particular should be re-examined.

Other aspects of Chatters' reconstruction linked to the hypothesized changes in base level include increased extent of the riparian zone in the mid-Holocene and decreased area of rapids. These changes are not readily detectable in the kinds of sedimentary data collected at sites.

CONCLUSIONS

One conclusion of this analysis is that most of the sedimentary record from project sites is consistent with gradual downcutting by the Columbia River since 7000 B.P. At the qualitative level, there are no gaps in alluvial activity, either point bar formation or vertical accretion, and most sites exhibit sequences from lower bar to upper bar or overbank deposits--a typical fluvial deposition sequence that does not require changes in base level. Possible reversals in the downcutting trend were noted and should be examined using data collected specifically for geomorphological reconstruction.

Another conclusion is that nonclimatic influences on river activity--isostasy, downcutting through glacial sediments to local base level, reaching the bedrock channel, landslides, and the tendency to meander have been underestimated in interpreting sedimentary sequences in areas of the Columbia River. The diversity of depositional settings and local variation in vertical sequences also has been underestimated, particularly in terms of the need for carefully designed sampling schemes to extract reliable geomorphological data. In order to filter out climate-independent factors and local variation and obtain information about regional climatic change, geomorphological data such as elevation of formations and sedimentation rates must be collected with more precision from carefully selected localities.

Another conclusion is that interpretations of regional climate and regional environmental sequences should be kept at an extremely general level and that finer chronological resolution and more detailed pictures of environment should be reserved for local areas. The paleoenvironmental reconstruction presented by Chatters (1984c) is too detailed to be applicable to the entire Plateau, and relies too much on extrapolation from other areas to be an accurate depiction of paleoenvironments in the Chief Joseph project area. Hopefully, further analysis of the sedimentary site sequences in the Rufus Woods reservoir will allow construction of a more accurate resconstruction, along similar lines as Chatters (1984c) but with more attention to local variability and climate-independent changes.

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SECTION III: TEMPORAL AND SPATIAL DISTRIBUTION OF COMPONENTS

A fundamental goal of the project has been to interpret, from site distributions and site content, prehistoric land use in the project area, thence to infer certain aspects of settlement patterns and subsistence strategies. We recognize that the project area does not necessarily include any entire settlement pattern or subsistence system, but our goal is not the description of a complete settlement/subsistence pattern. Assessment of change in subsistence strategies on the continuum from foraging to collecting (Binford 1980) does not necessarily require the entire system but may be made on part of the system. The ethnographically described susbsistence strategy on the Plateau was a collecting system with a strongly logistical organization, and one of the most significant contributions we can make is to examine the developmental history of this adaptation. As discussed by Leeds (Chapter 7), the logistical organization was long assumed by archaeologists to have developed relatively late in time, but the discovery in the late 1970's of much older housepits and apparent sedentary occupation raised the question of the antiquity of the logistical pattern.

Each of the papers in this section concerns some aspect of the distribution of sites of different types in time and space and the interpretation of settlement/subsistence patterns therefrom. While it is a relatively simple matter to tabulate sites or assemblages through time or map their distribution in space, in inferring from these to subsistence strategies and settlement patterns, the archaeologist faces a creative challenge in distinguishing cultural patterns from patterns introduced by sampling biases, analytic methods, and other noncultural determinants of pattern in the data.

In his investigation of the relationship between the locations of different kinds of sites and various environmental features at the project, carried out in 1981, Leeds introduced Binford's concept of logistical hunting/gathering systems to interpret the prehistoric record from our area. From this model he developed hypotheses about site location to test using data from the survey and testing program. His analysis of site clustering and environmental influences on siting (Chapter 7) indicates that different types of sites were influenced by different siting factors, and that housepit sites were influenced by ranked siting factors as predicted for central bases.

Salo has carried forward the work on site types and site distribution, influenced as well by the work of Chatters (1984) in the upper portion of the reservoir. In Chapter 6 he defines three types of sites, develops contrasting expectations for their contents in logistical and foraging systems, and tests these expectations against project data. In Chapter 8 he develops expectations for the proportional representation and spatial distribution of the site types. His locational analysis builds on the basis established by Leeds but has a finer temporal resolution, examining site distributions in three 2-thousand year periods. The study also incorporates information on inundated sites taken from pre-reservoir aerial photographs (the photogrammetry project is described in Appendix E) to offset biases in site inventory caused by differential degree of inundation along the length of the study area.

Essential to the study of archaeological materials, particularly the study of cultural change, is the temporal ordering of archaeological assemblages. The chronological structure used most extensively in this report is the three-part phase system developed for the project by Lohse and Jaehnig in the spring of 1983 and announced in a paper at the Northwest Anthropological Meetings (Jaehnig 1983). The announcement evoked very different responses from the discussants; some found it reasonable that we define a set of phases for our specific region, while others argued agaist what they perceived as an unnecessary proliferation of labels. This debate arises partly out of different concepts of what phases are and should be. Traditionally, culture historical phases have content tied to specific regions in which they occur; they are based on artifact types and carry implicit assumptions about cultural development and adaptation. Regional variants deserve recognition as separate phases. With the help of radiocarbon dates, archaeologists have escaped from the circularity of using the same data--artifact types--to chronologically order assemblages and to interpret the meaning of differences. We must plead guilty to using the term **phase** for what are actually time periods defined by absolute dates. We could more accurately have termed these the Kartar, Hudnut, and Coyote Creek Periods. However, we make no apology for introducing another set of names into the Plateau literature. Our data base is certainly large enough to warrant its own labels, and we preferred to begin our interpretations of the prehistoric record without the prejudice of existing phase names that carry implications about cultural content.

Even with radiocarbon dates, however, it is not possible to arrange our archaeological data in chronological order like points in absolute time. Most assemblages we recover span a period of time, and rarely are the endpoints known. If we compared assemblages arranged into the maximum number of time intervals the effects of sampling biases would be accentuated because of the small numbers in each interval. Therefore, we commonly use larger time intervals to aggregate the data so that it is possible to make comparisons. Although useful for recognizing general trends, periodization of any sort imparts an artificial structure to the data. We tend to assume homogeneity within periods and to concentrate on contrasts between periods. The arbitrary structure thus masks the fact that change, while not necessarily gradual, happens over some length of time. Always, when we choose temporal analytic units, there is a tradeoff between the advantage of shorter intervals in detecting change, and the problem of decreasing reliability of samples as the intervals get shorter.

Both Salo (Chapter 6) and Miss (Chapter 9) consider the problem of periodization in more detail. While we generally found the 2000-year phases to be useful time intervals for organizing our detailed descriptions of individual sites into broader generalizations about the prehistoric record, the study by Miss demonstrates the potential and the importance of using finer time periods. She shows the different distributions of site frequency through time which result from using 500 and 1000-year periods. Her comparison of site types and temporal distribution of cultural debris complements that of Salo (Chapter 6) in that she considers material density by 1000-year periods rather than by phases, and considers rates of accumulation as well.

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6. LARGE-SCALE ANALYTIC UNITS: CHRONOLOGICAL PERIODS AND SITE TYPES

by Lawr V. Salo

This chapter develops a framework for analyzing the project's data to identify and describe the prehistoric land use and settlement patterns that were characteristic at varying times in the history of human use of the area. Chapter 1, by Leeds and others, discussed the background of inquiry into land use and settlement pattern studies of hunters and gatherers as it stood in the early part of the 1980s and acknowledges the project's debt to its intellectual progenitors. Since Leeds' team completed its work, other local archaeological research projects have significantly affected the way we view the project's data as they may reveal details of local prehistoric land use and settlement patterns.

Among these is Dr. Leeds' site location analysis (Chapter 7) which developed distributional expectations for central bases and field camps in a logistically organized subsistence/settlement system and tested these using the survey data base. The other major influence comes from a cultural resource testing program carried out in the upper end of the project from 1982 to 1984 by Central Washington University under the direction of Dr. J. C. Chatters. This program developed a model for local prehistoric land use and settlement patterns and human paleoecology with conscious attempt to allow for archaeological testing and application (Chatters 1984a and b). The structure and intent of this chapter owes much to the work by Chatters, although we have revised some of his framework because of practical considerations.

In particular, this chapter is concerned with the chronology of the occupations studied in the project area, functional interpretation of occupations, and biases in the project's record of the prehistoric past. In studying the occupations' chronology and structure we have elected to employ only the simplest of quantitative measures as time and resources do not permit more elaborate approaches. The data base is the most systematically collected series of assemblages yet available from any area in the Plateau and considerable caution was exercised to see that it would be as representative of the archaeological record in the project area as conditions would permit. However, we do not assume that our sample is statistically representative. The sites were selected for data recovery in a purposeful fashion, and the purposive and random samples from the sites' assemblages were not reported separately in the descriptive site reports. We view the data critically, pointing out biases whenever possible in the interest of guiding future research with the project's collections.

Data for the following discussions are taken from tabulations in the project's descriptive site reports. The summary tables and graphics in this chapter are derived from raw counts of materials categories by analytic zones or components assembled in the tables of Appendix D.

CHRONOLOGICAL ORDERING

The chronologic structure for investigating the project's paleoecology or land use-settlement patterns must address two main problems. It first would have to support studies to disclose trends in these aspects of the local pehistory. Then it would have to show when changes took place, with the greatest feasible accuracy.

There is considerable direct and indirect evidence of prehistoric land use change. In the past twenty years, other investigators in the northern part of the southern Columbia Plateau have noted that archaeological populations increase and decline at various times in the past 8-10,000 years. (The term "archaeological populations" is used here rather than "populations" to avoid the immediate implication that the actual human populations change.) Various studies have observed that archaeological populations from different time periods have different characteristic locations, both at the scale of regions measured in hundreds of square kilometers and at local scales measured in meters or tens of meters (Galm et al. 1981; Mierendorf et al. 1981). For instance, at the regional scale, certain archaeological phases (Cascade, Early Frenchman Springs) or time periods are not well represented in the Columbia Basin, while surrounding areas along major rivers show sizeable occupation during the same time period. At the local scale, the lowest landforms along many reaches of the Columbia River formed within the last 4,000 years, and do not bear evidence of the older Cascade cultures (Fryxell, 1973; Chatters, 1984b). The project itself found that occupations from about 4500 to 2500 years old, or those of Frenchman Springs Phase age (Nelson 1969) seemed to be very common (Jermann et al. 1978).

To approximate occupation frequencies for the project and compare them with other reported data, we summed radiocarbon dates by 100 year interval, omitting single standard deviation ranges for graphic clarity. The results were expressed as frequency bar charts for each project. We also added a curve schematically expressing the frequency and intensity of mountain glaciation in the Columbia River basin to suggest where the boundaries of paleoclimatic regimes might be found.

The many occupation assignments made simply by stylistic analysis are omitted, resulting in proportionally low representation of occupations at the near end of the scale, where carbon is too recent to date well, and at the far end, where occupations on long-stable or erosional surfaces have poor organic preservation, hence poor representation in the radiocarbon data. Dates from the Chief Joseph and Priest Rapids/Wanapum Dam projects are dendrocorrected after Damon et al. 1974 if older than 363 years (see Appendix D, Table D-4 for a summary of Chief Joseph Dam Project radiocarbon data). Kettle Falls dates are corrected similarly after Sheppard 1975. Dates older than 4000 years from

Wells Reservoir are dendrocorrected and the younger are not. The dates for the glaciation curve are dendrocorrected after Damon et al. 1974. All archaeological dates are from sites within riverine flood plains. Most are within 60 vertical feet of normal high water along the river; all are within 150 feet. There are no dates at the Chief Joseph Dam project over 5600 years, nor do projectile points from several older but undated occupations suggest dates exceeding 6500 years. At the Chief Joseph Dam project, nearly every occupation at each data recovery site is dated, and about 25 percent of occupations at tested-only sites are dated. Most dates have single standard deviations within about 150 years.

The results of the exercise are illuminating (Figure 6-1). Each reach of the Columbia River shows some kind of cycling in archaeological populations. The fluctuations seem to coincide with climatic changes implicit in the retreat and advance of mountain glaciers. Why cycles are present, if they are indeed present, is a major question. At this point we do not know if changes in frequency of radiocarbon dates reflect changes in human population density, changes in land use patterns that resulted in greater dispersion of human population, natural processes that preserve or destroy sites, or sampling bias.

If the cycles are evidence of human population changes, there is a strong likelihood that change in land use and settlement patterns underlies them. Ideally, we would examine change in the human paleoecology of the project using the most finely divided time periods available, possibly on the order of 100 years or so. We are unable to do so for many reasons, none of them unique to this project. If we split the project's temporal universe of 6000 years into 60 century-long intervals there would be a great many empty intervals. Many of the occupations span several 100-year periods. Some occupations, particularly older ones and those representing short-term, transitory activities, can be assigned to intervals only on the basis of probabilities given by index fossils (projectile points). In most instances, the assignments are on the order of millenia in length.

For purposes of the summary analyses we wished to define time periods longer than 100 years but shorter than the three 2,000 year phases, or historical periods previously defined by Jaehnig and Lohse (Jaehnig 1983). Two schemes alternative to the phase system were developed, an interval scheme and a subphase scheme. Interval and subphase assignments were made for all assemblages; however, we ended up relying almost entirely on the phases for our comparison. The details of these finer periodizations are presented below as they may be of use to future researchers.

The interval scheme uses roughly 500-year long intervals for the most recent 2000 years of prehistory, then 1000-year divisions for all previous time. The historic period was divided into four intervals based on known changes in economic factors (horse acquisition, beginning of fur trade, population concentration on reservations/reliance on agriculture; and the modern automotive industrial era.) We selected 500-year intervals for the last 2000 years to facilitate study of changes within that period; the subdivisions can be grouped for comparability with other periods.

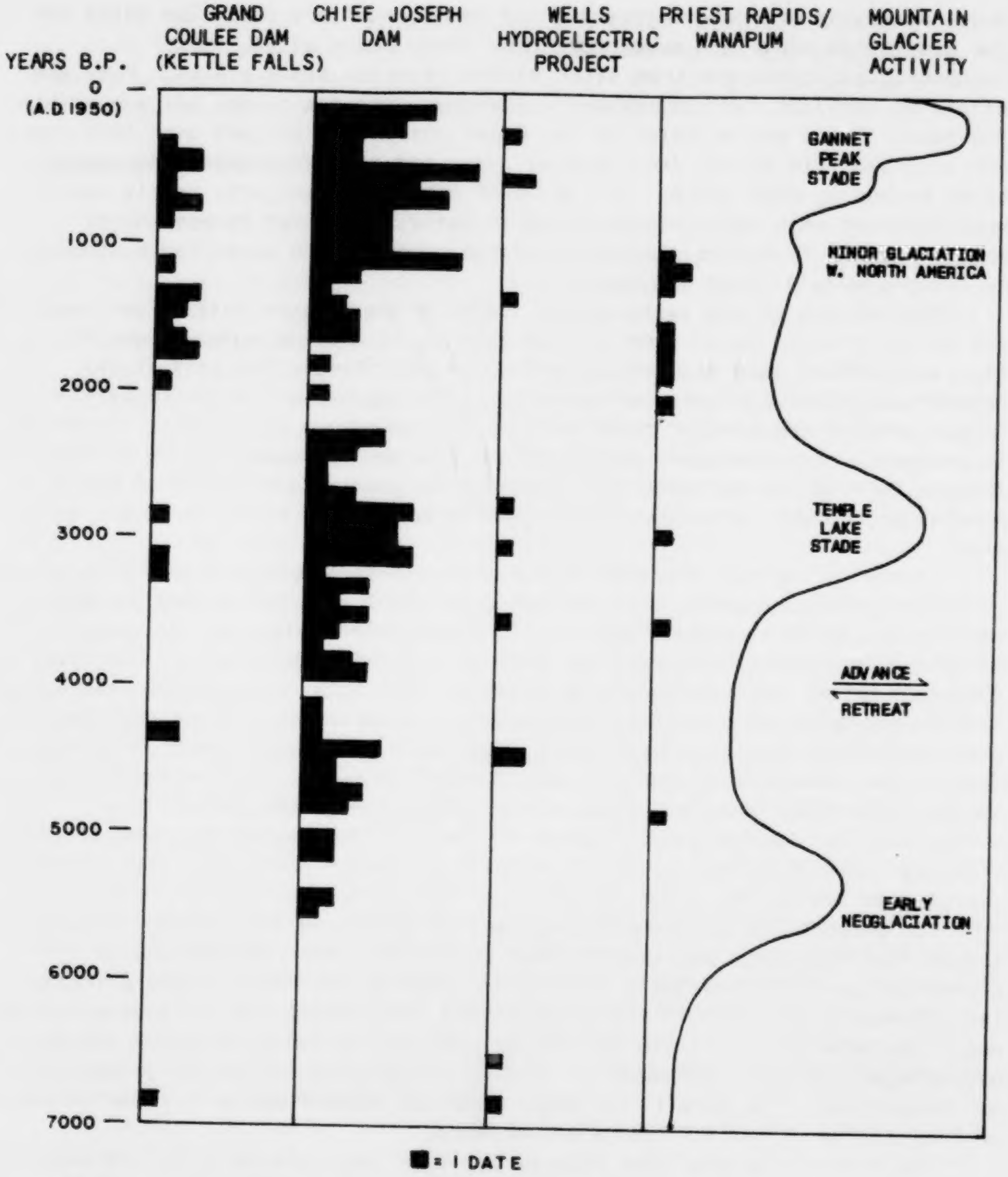


Figure 6-1. Temporal distribution of radiocarbon dates reported by archaeological projects in the northwestern Plateau. (Dates obtained from Chance and Chance 1977, 1979, 1982; Chance et al. 1977; Grabert 1968; Greengo 1982; Table D-4, Appendix D. Mountain glacier activity after Denton and Karlen 1973; Porter and Denton 1967; Miller 1969; Alley 1976).

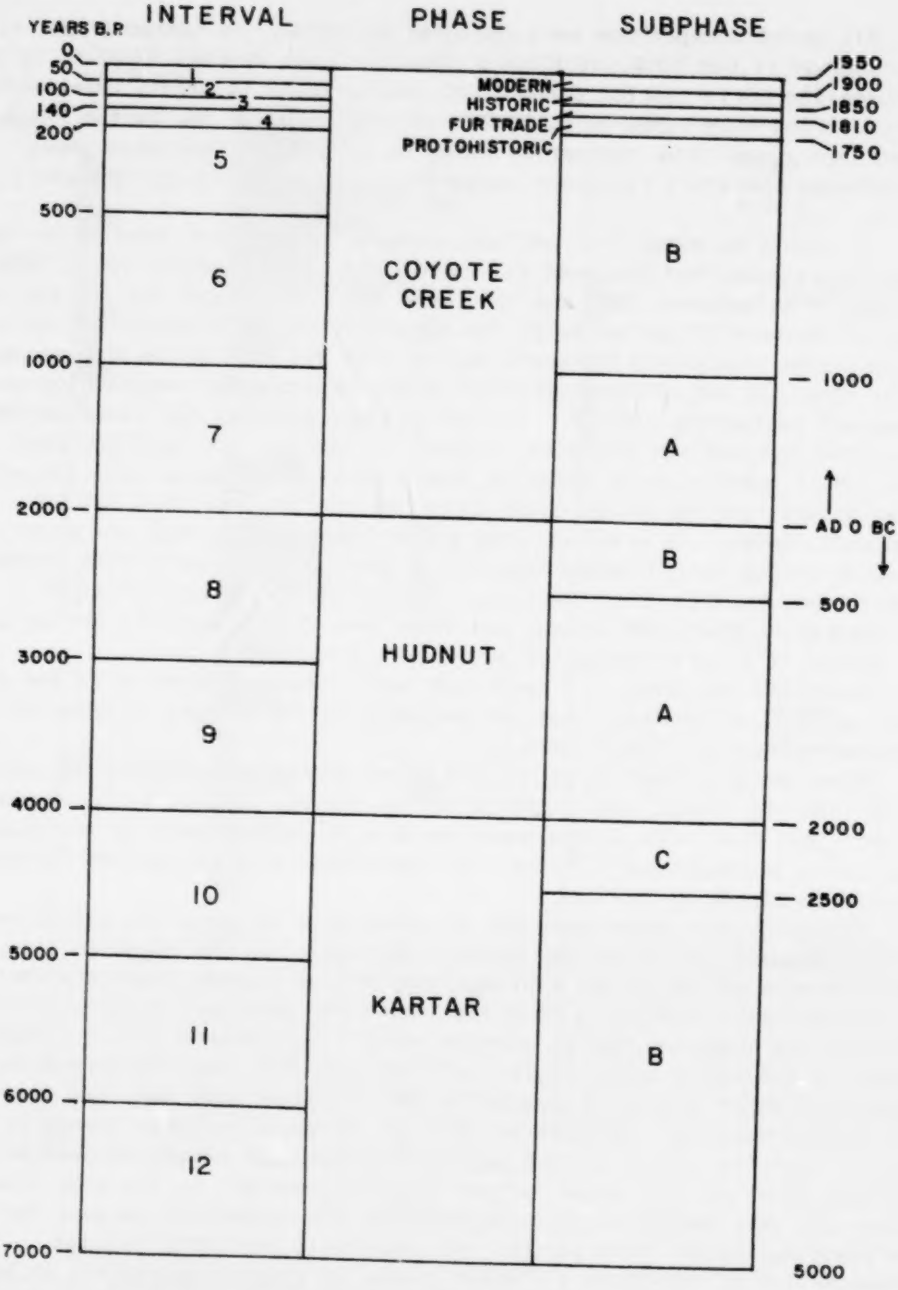
All dated occupations were assigned to either the Kartar (7,000 to 4,000 B.P.) Hudnut (4,000 to 2,000 B.P.) or Coyote Creek Phase (2,000 to 50 B.P.). Although the Kartar period spans 3,000 years, there is little representation of the period from 7,000 to 6,000 B.P. so that bulk of the Kartar Phase assemblage comes from the period 6,000 to 4,000 B.P. The three phase assemblages therefore represent comparable time spans of approximately 2,000 years.

It should be noted that we have changed the temporal span of the Coyote Creek Phase from that proposed by Jaehnig and Lohse (Jaehnig 1983), who defined it as between 2000 and 150 years B.P. They chose the 150 B.P. as the endpoint because it approximates the beginning of the historic period in the project area; the historic record begins with the trip of David Thompson in 1811. They did not define a distinct phase to accomodate archaeological materials postdating 150 B.P. Yet the project analysis has revealed several aboriginal occupations which begin prior to 150 B.P. and continue past that date. Most notable among these is Zone 1 at 45-OK-2, which includes well-dated houses ranging in age from about 500 B.P. to less than 100 B.P. (Campbell 1984a). In practice, the project has treated this and other historic period aboriginal components as part of the Coyote Creek Phase. We have formalized this practice here. There is no justification at this time for separating post-1800 occupations from pre-1800 occupations and we prefer the phases to be arbitrary time periods of comparable length.

Subphases (as shown in Figure 6-2) were created primarily to see if there were cultural differences that corresponded to the changes in apparent site frequency construed from Figure 6-1.

When the distribution of the project's component inventory was compared using interval, phase, and subphase dating systems (Figure 6-3), it was evident that the phase system would be able to support most of the studies we required with the fewest difficulties (see Miss, this volume for further discussion of periodization).

There are both advantages and disadvantages to using the phases as our primary temporal units for our summary analyses. On the negative side, the ethnohistoric period is not distinguished and we suspect there are variations in occupational intensity within the 2000 year intervals (Figure 6-1). Although the phase boundaries were selected to correspond with noticeable breaks in projectile point style distributions, they also correspond to what seem to be major breaks in population density about 4000 and 2000 years ago. Site data grouped by these phases thus can serve to indicate trends in the general characteristics of each period or phase, but cannot be used to disclose what led to changes between adjacent phases. On the plus side, the phases are very useful units of aggregation and comparison because they represent equivalent time periods and comparable excavated volumes. Repesentation of the three different phases is roughly equivalent in both numbers of zones and volumes recovered when only chronologically pure salvage zones are considered (see Table 6-4 for listing). As can be seen in Table 6-1, representation of the Hudnut Phase slightly exceeds that for the other two phases. The distribution mirrors the selection of components for salvage by


YEARS B.P.
INTERVAL
PHASE
SUBPHASE
0
50
100
140
200
500
1000
2000
3000
4000
5000
6000
7000
1
2
3
4
5
6
7
8
9
10
11
12
COYOTE CREEK
HUDNUT
KARTAR
MODERN
HISTORIC
FUR TRADE
PROTOHISTORIC
B
A
B
A
C
B
1950
1900
1850
1810
1750
1000
AD 0 BC
500
2000
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5000

Figure 6-2. Interval, phase, and subphase chronological divisions.

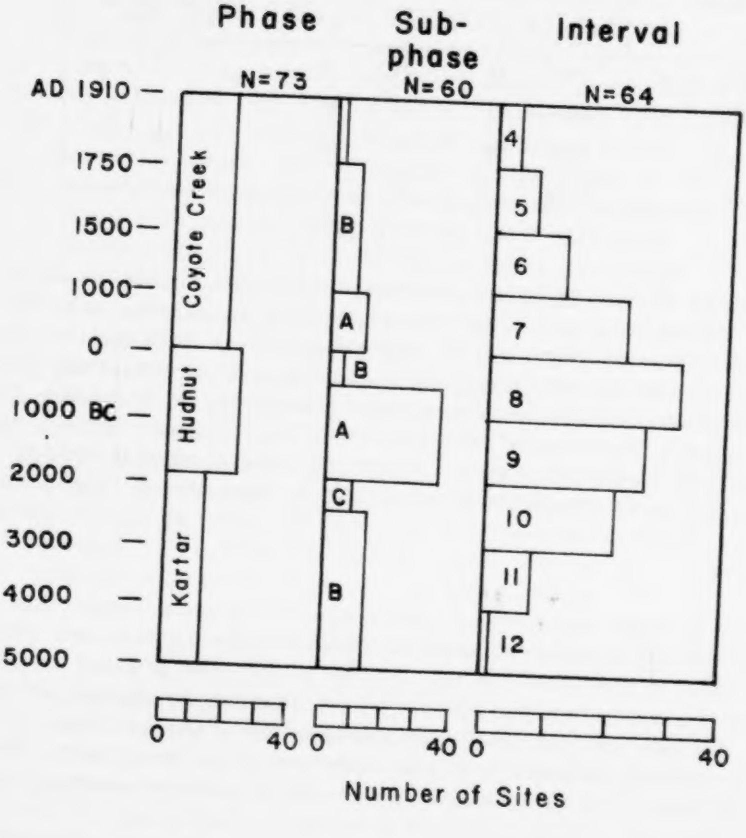

Figure 6-3. Frequency of components by phase, subphase, and interval.

the project (Campbell 1984b). Comparisons of phase characteristics on a gross integrative level should not be overly biased by sample volume or size differentials.

Table 6-1. Sample size by phase.

Phase	Total Volume		Analytic Zones		Average Volume/ Zone (m^3)
	(m^3)	%	N	%	
Coyote Creek	1281	34	21	36	61
Hudnut	1466	38	21	35	70
Karter	1051	26	17	29	62
Total	3798		59		

For nearly all comparative purposes, mixed components where stylistic indicators and radiocarbon dates crosscut phase boundaries are not used. There are very few of these cases, and they involve only small assemblages. In three instances, we have assigned assemblages with minor degrees of mixing to a single phase because the overwhelming majority of indicators suggest that occupation took place almost entirely wthin that phase. These sites and occupations are 45-DO-211 Zone 5, 45-DO-326 Zone 4, and 45-OK-250 Zone 51. Radiocarbon dates of occupations are shown in Appendix D, Table D-4.

SITE TYPES

The other major category of analytic unit is site type. Our classification is designed to develop functionally significant statements about prehistoric use of different places within the project area. As with the time units, we intend to identify only the larger changes in prehistoric land use. In view of the limits imposed on the study by time, funding, and the data themselves, we restrict our examination of functional and environmental patterning to but a few of the dimensions used by other investigators.

Chatters (1984a) has modelled adaptive systems of collectors, foragers, and the ethnographic Sanpoil-Nespelem using the dimensions of occupation area, duration by seasons, floral and faunal diversity, seasonal geographic displacement, firebroken rock size, faunal fragment size, discreteness of features, tool and feature diversity, and interassemblage variation in tools, features, and plant and animal species. He has developed ranked expectations for forager base and location camps and collector's base camps, field camps, locations, stations, and caches (Chatters 1984a:Table 1). Likewise, his model provides expectations for Sanpoil-Nespelem winter villages (base camps), winter hunting camps, spring camps, early and late root camps, early and late summer and fall fishing camps, and berrying/hunting camps (Chatters 1984a:Table 2). Several years before Chatters completed his modelling of the local ethnographic land use pattern, Leeds had modelled several aspects of it using a different approach (Leeds et al., Chapter 1). Leeds' model did not progress to the stage of testing nor was it designed to detect changes in land use patterning, but its dimensions contained several elements that appear to be useful in identifying variability characteristics of tool, feature, and faunal assemblages that might be associated with different adaptive systems. Specifically, these were expectations of kinds of feature, traditional tool classes, botanic and faunal remains that would be assocated with Sanpoil-Nespelem winter villages, summer fishing villages, spring villages, tule camps, root camps, hunting camps, quarrying camps, quarrying workshops and caches, butchering camps (see Figure 1-18). Combined with Chatter's elemental probabilistic approach, it appears to offer a fairly economical method for disclosing adaptive changes. After examining the kinds of data available from the project, we decided that many of the dimensions of Chatters' model would be overly difficult to approximate; we also felt that fewer crucial dimensions might yield better results in disclosing patterns of change.

Our examination of settlement pattern change therefore focuses on four main dimensions: variability in characteristic arrays of features; intensity of site use as measured by modes in density of common cultural debris such as unidentified bone, shell, and fire modified rock; tool variability and richness as measured by counts of functional classes and indices of diversity (richness); faunal variability and richness as measured by frequency data on selected taxonomic groups and indices of faunal diversity. The variability in faunal assemblages can be used not only to investigate adaptive strategies but environmental change as well. We have not included measurement of the various aspects of seasonality in this preliminary work because this dimension is simply too complex to control (see Livingston, Chapter 12). We did not attempt a systematic analysis of diversity of botanical assemblages because too few were analyzed. Information on botanical assemblages may be found in Chapter 13.

Using the foregoing dimensions and referring to Leeds' and Chatters' work, we have constructed a revised model of expectations for the characteristics of kinds of sites that we believe are associated with forager or logistic adaptive systems (Table 6-2). We defined only three kinds of sites as it is unlikely that we could detect more using the above dimensions. However, using the model provided it should be possible to assess relative distances along the continuum between the two different kinds of systems.

Operationally we commenced our study of the area's prehistoric adaptive systems by examining the distribution of site types in space and time (Salo, Chapter 8) using site types based on feature arrays. We selected the feature site type because we wanted to classify as many sites as possible for the locational study, using both survey and salvage data. The feature site types appeared to give the best hope of including data that otherwise would not be usable. Biases introduced by this approach are discussed in Chapter 8. This chapter cross examines the feature site types against other variability dimensions to examine the utility of the feature site types as an analytic device for studying adaptive system change. While many other kinds of site

Table 6-2. Site variability characteristics of collecting and foraging systems (Sanpoil-Nespelem analogue).

Dimension	Kind of Site					
	Central Base[1]		Field Camps[2]		Location/Station[3]	
	System		System		System	
	Collecting	Foraging	Collecting	Foraging	Collecting	Foraging
Feature Variability						
Type frequency						
House floor	1	1	3	–	3	3
Living floor	2	1	1	–	3	3
Midden	1	1	2	–	3	3
Earth oven	2	3	1	–	3	3
Hearth	1	1	2	–	3	2
Pit	1	2	2	–	3	3
Cache	1	2	2	–	3	3
Other	1	1	2	–	3	3
Use Intensity						
Density n/m^3)						
Bone	1	1	2	–	3	3
Shell	1	1	2	–	3	3
FMR	1	1	2	–	3	3
Tool Variability						
Type frequency						
Abrading	3	2	1	–	2	3
Milling	1	2	2	–	3	3
Carving	2	2	1	–	3	3
Sawing	1	2	3	–	3	3
Awling	1	2	2	–	3	3
Drilling	1	2	2	–	3	3
Projectile impact	1	2	2	–	3	2
Chopping	1	2	2	–	3	3
Flaking	2	2	1	–	3	3
Pounding	1	2	2	–	3	3
Hard scraping	1	2	2	–	3	3
Soft scraping	2	2	1	–	3	3
Weighting	1	2	2	–	3	3
Decorating	1	2	3	–	3	3
Diversity (# of types)	1	2	2	–	3	2
Faunal Variability						
Mammal NISP						
Small Herbivore	3	1	2	–	1	3
Large Herbivore	1	1	2	–	3	3
Fish NISP						
Salmonid	2	1	1	–	3	3
Other	1	1	2	–	3	3
Reptile/turtle	1	1	2	–	3	3
Density (n/m^3						
Mollusc (shell)	1	1	2	–	3	3
Richness (# of taxa)	1	1	2	–	3	3
Use Intensity #/wt (x̄ fragment size)						
Bone	1	1	2	–	3	2

[1] Winter village

[2] Spring village, fishing camps, root camps.

[3] Salt licks, quarry camps, butchering camps, tule camps, kill sites.

KEY: 1 = High, 2 = Intermediate, 3 = Low types could be created using the project's data base, the following analyses establish the general utility of the feature site types for identifying and describing major differences in prehistoric land use.

FEATURE SITE TYPES

We elected to use characteristic arrays of features as the primary analytic device to classify sites into types that would be analogues for different kinds of sites that other researchers believe may be associated with different kinds of hunter-gatherer adaptations. This practice has been used on a less formal basis for many years to organize inquiry into prehistoric economy in the Plateau, and we saw no reason to abandon the general approach. Features are excellent for classifying components into site types because feature assignments to components are highly reliable and because they are more direct evidence of activity locations than are portable artifact types.

Feature Superclasses

Because the project has over 32 reported kinds of features, we found it necessary to group several diverse categories into larger, more functionally useful classes. We created the following classes to subsume more detailed information:. house floor/housepits; living floors; midden; hearths; earth ovens; pits; caches; and the residual class of other. The following paragraphs discuss how each superclass was created, the reasons for creating the class in the first place, and the research assumptions involved.

House floors/ housepits is the most straightforward of all categories. House floors always were tallied separately as were discrete features associated with houses. Definition of this class follows Sammons-Lohse (Chapter 14). We assume houses represent intensive residential or domestic activity, but we make no assumptions about seasonality.

Living floors includes occupation surfaces with evident structure and relatively discrete boundaries. We assume that living floors represent a less permanent domestic usage of a location than house floors/housepits, due to the lesser investment of labor in their construction.

Midden is the most inclusive superclass, subsuming bone, FMR, rock, shell or mixed debris concentrations or scatters; cultural stains; strata of dense cultural materials; housepit fill; and lithic concentrations. Occasionally occupational surfaces were included if they lacked discrete structure or other characteristics of nonenclosed domestic living surface. We assume that midden presence reflects more intense site use than midden absence, given equal preservation.

Earth oven includes only features reported as such. There may be discrepancies in the definition for earth ovens among the different sources, so this category may include both steam pits and enclosed dry roasting ovens. The class is included to contribute data on the degree of sophistication present in the control of fire and possibly on diversification of site functions. We assume that greater diversity in the structures for fire control will indicate a more intensively adapted cultural system.

Hearth includes surface hearths, oxidized soil, and firepits. It is included for the same reasons as earth ovens, but may bear somewhat more on the domestic functions of an area than on other kinds of subsistence activity. We assume that hearths indicate focused activity and food consumption.

Pits include only pits. They are possible evidence of storage and may be indicators of logistical behavior.

Caches include tool clusters and artifact caches. They may include lithic concentrations if the latter show very tight clustering indicating intentional storage. We assume that caching is an indicator of logistical behavior.

Other features is a residual class which includes petroglyphs, rock alignments, burials (human and canid) and isolated postmolds. The class illustrates site complexity and depositional integrity, and facilitates accounting. It involves no major research assumptions.

Data on the project's feature inventory are contained in Appendix D, Tables D-2 and D-3.

Site Classification

We then selected three types of feature associations likely to be found in sites corresponding to central bases, field camps and locations/stations that might be found in some kind of logistical adaptive system. We classified each component according to its constituent features. This system is also a rough index of a site's feature diversity. Relative frequency of feature superclasses by phase is discussed by Miss (Chapter 9) and variations in formal structure and content of features by phase is discussed by Sammons-Lohse (Chapter 14).

Site Type 1 is defined as a component with a housepit or housefloor and at least one other kind of feature, excluding midden. We use this type as a surrogate for central bases, corresponding to the commonly used special case term "winter village". The one other feature provision is added to include evidence of logistical behavior beyond construction of dwellings. In fact there were no components with evidence of houses which did not have associated midden and at least one feature other than midden.

Site Type 2 is defined as a component with a living floor and one other feature, or a midden and one other kind of feature. We use this type as a surrogate for field camps, or "open camps". We found that in components fitting this definition the other feature was almost invariably a hearth. Components assigned to this type may include some which are actually parts of Type 1 sites in which the houses had been destroyed earlier or were not encountered in our excavations.

Site Type 3 is defined as a component with one or no feature. The type is a surrogate for locations/stations, or "open camps", root camps", "kill sites", quarries", "lithic scatters" and the like--low density/low material diversity and relatively non-discrete sites. This category may include remnants of Type 1 or Type 2 sites, but there are surprising indications in associated contents that this is not usually the case. We could not support splitting the Type 3 sites further to separate locations from stations, as the numbers in each resulting category would be too few in each time period to permit meaningful resolutions of spatial distribution patterns. Furthermore, to show degree of logistical organization, it did not seem necessary to have such refined control.

All sites, whether tested or salvaged, were classified in this system insofar as possible. In some cases with survey sites, it was necessary to decide to which of two components untested housepits should be assigned. In these cases, the houses always were assigned to the component with the highest and most even overall general debris (bone, FMR, and shell) densities, as there is a high correlation between high even densities and housepit sites (see discussion of density types below). There were few difficulties in typing salvage site components, but on occasion it was not easy to decide whether an occupation surface was a living floor or a sheet midden.

Biases

There are biases in the data from salvage sites caused by purposive sampling (see Campbell 1984b for detailed discussion of sampling strategies used at all sites). Most intensive sampling focused on housepit sites. We have a larger sample for Type 1 sites than the other site types, as measured by volume, although not as measured by number of analytic zones (Table 6-3). All subsequent comparisons among sites must take this bias into account. Even if analytic zones with unusually high sampling volumes are removed from the inventory (both zones at 45-OK-11), the bias still is pronounced. As we have noted before, feature diversity tends to reflect sampling intensity in a given kind of site, so typing sites solely by their feature diversity has analytical limitations.

Table 6-3. Sample size by feature site type.

Feature Site Type	Total Volume		Analytic Zones		Average Volume/ Zone (m^3)
	(m^3)	%	N	%	
1	1775	47	13	22	136
2	1139	30	18	30	63
3	8841	23	28	48	31

DEBRIS DENSITY SITE TYPES

Debris density site types were created primarily as a cross-check of the usefulness of the feature site types. Density of all materials indicates intensity of site use, and incidentally sheds light on area demographics.

A cross check was particularly desirable as debris density theoretically was less likely to have a positive correlation with sampling intensity at the same level as feature diversity (Jermann 1981). If some kind of positive feature correlation between feature site types and debris density site types could be established, then we believed that using feature site types to investigate site clustering and settlement patterning would be more defensible.

Count or weight per unit volume for bone fragments, mussel shell, and fire-modified rock were calculated for each chronologically unmixed analytic zone for each salvage site. We examined the distribution of values, finding generally bimodality but no striking multimodality. We divided the range in two, choosing a slope change for the dividing point. An alphanumeric designator was assigned to the low and high divisions (1 or 2 respectively).

Bone

We used bone count as the density indicator for this material. There seemed to be little variation among sites in fragmentation indices (count/weight) ratios; it seemed likely that there would be fewer errors in counting than weighing. We assume that preservation is roughly equal for all time periods when large numbers of assemblages are combined for comparisons. Distribution of bone count density and component designators are shown in Table 6-4 along with density data for shell count and FMR weight. Less than 300 fragments of bone per cubic meter were designated low (indicated by alphanumeral 1); high density (designator 2) was equal to or greater than 300 fragments per cubic meter.

Shell

Most of the mussel shell from the project probably is Margaritifera falcata, based on survey findings (Leeds et al. 1981). We were constrained to using only counts because weights were not recorded consistently among sites. Fewer than 60 pieces of shell per cubic meter was considered low density (designated as 1); greater than or equal to 60 was high (designated as 2).

Fire-modified Rock

Fire-modified rock (FMR) weight rather than count was used to generally indicate intensity of use of an area. Specifically this dimension was considered to investigate the use and control of fire, and secondarily to contribute information of value to demographic studies. Densities less than 2 kg per cubic meter were considered low (designated as 1); those equal to or greater than 2 kg were considered high (designated as 2).

Table 6-4. Listing of components assignable to phases showing feature and density site types and debris density data.

Site	Zone	Phase	Feature Site Type	Density Site Type	Volume	General Debris Densities				
						Bone		Shell	FMR	
						Count	Weight	Count	Count	Weight
45-00-204	1	Coyote Creek	2	111	64	8	1	0	4	1025
45-00-204	2	Hudnut	3	111	32	72	16	0	6	798
45-00-204	3	Kartar	3	111	28	64	10	0	7	885
45-00-204	4	Kartar	3	111	32	22	2	0	1	39
45-00-211	2	Hudnut	3	122	28	27	17	133	14	2238
45-00-211	3	Hudnut	3	121	41	89	18	89	6	1052
45-00-211	4	Hudnut	1	222	33	358	68	68	15	2484
45-00-211	5	Hudnut	1	111	29	79	25	11	3	551
45-00-214	1	Coyote Creek	2	111	63	117	30	4	5	882
45-00-214	2	Coyote Creek	2	212	31	664	212	4	34	7111
45-00-214	3	Coyote Creek	2	211	33	706	281	6	7	1505
45-00-214	4	Hudnut	3	121	63	66	23	114	4	686
45-00-242	1	Coyote Creek	2	112	31	115	14	57	21	6188
45-00-242	2	Coyote Creek	2	112	33	173	53	31	14	7781
45-00-242	3	Hudnut	1	212	70	698	286	45	16	3938
45-00-242	4	Kartar	3	111	20	29	10	0	1	294
45-00-243	1	Coyote Creek	3	111	25	41	14	0	1	63
45-00-243	2	Hudnut	2	111	23	102	46	11	1	124
45-00-243	3	Hudnut	2	111	18	126	49	53	0	279
45-00-243	4	Kartar	3	111	18	45	27	6	0	12
45-00-273	2	Coyote Creek	3	111	30	21	5	0	3	651
45-00-273	3	Kartar	3	111	38	5	1	0	2	320
45-00-273	4	Kartar	3	111	29	1	0	0	0	6
45-00-273	5	Kartar	3	111	18	0	0	0	0	0
45-00-282	1	Kartar	3	111	45	2	1	0	0	0
45-00-282	2	Kartar	3	111	41	1	1	0	0	23
45-00-282	3	Kartar	3	111	53	1	0	0	0	21
45-00-282	4	Kartar	3	111	47	0	0	0	0	0
45-00-285	1	Coyote Creek	3	112	53	125	28	0	16	3035
45-00-285	2	Coyote Creek	3	111	25	91	20	0	2	51
45-00-285	3	Hudnut	3	112	29	292	125	0	24	4887
45-00-285	4	Hudnut	3	112	29	244	121	0	20	5584
45-00-325	1	Coyote Creek	2	212	25	767	181	0	15	2831
45-00-325	2	Coyote Creek	3	211	24	722	132	0	7	1480
45-00-325	3	Hudnut	2	212	13	2281	291	0	15	2198
45-00-325	4	Kartar*	3	211	31	730	108	0	0	128
45-OK-2	1	Coyote Creek	1	212	153	444	88	17	68	14241
45-OK-2	2	Coyote Creek	1	222	132	675	142	158	53	12875
45-OK-2	3	Hudnut	1	222	98	454	113	245	32	5703
45-OK-2	4	Hudnut	2	222	86	422	127	294	15	3813
45-OK-9A	1	Coyote Creek	2	112	21	288	59	8	44	5382
45-OK-9A	2	Hudnut	1	212	21	318	67	20	15	2522
45-OK-9A	3	Kartar	3	111	21	44	8	4	1	355
45-OK-9A	4	Kartar	3	111	16	17	3	1	0	7
45-OK-4	51	Coyote Creek	2	112	113	202	39		17	2957
45-OK-4	52	Hudnut	1	222	93	1678	436		51	8019
45-OK-11	A	Hudnut	2	112	307	182	40	33	14	2399
45-OK-11	B	Kartar	1	222	572	352	159	324	12	1884
45-OK-18	2	Hudnut	2	111	50	33	3	0	10	1077
45-OK-18	3	Hudnut	3	111	42	16	1	0	0	28
45-OK-18	4	Kartar	3	111	8	15	1	0	0	0
45-OK-290	51	Coyote Creek*	2	222	138	583	124	139	21	3281
45-OK-290	52	Hudnut	1	222	159	1046	231	313	27	4087
45-OK-258	A	Coyote Creek	1	222	165	881	338	87	34	3418
45-OK-258	B	Hudnut	1	222	201	1157	353	230	33	4451
45-OK-287/8	1	Coyote Creek	3	111	20	16	23	0	0	55
45-OK-287/8	2	Coyote Creek	2	112	49	89	23	1	14	7090
45-OK-287/8	3	Coyote Creek	1	212	55	303	102	1	17	3083
45-OK-287/8	8	Kartar	2	112	39	201	40	1	10	2104

Weights are grams per cubic meter
Volume is in cubic meters
See text for definition of feature and density site types

Comparison of Feature and Density Site Types

It is evident that the feature site types represent different cultural phenomena when the distribution of density types among them is considered (Table 6-5). The first figure in each cell is count; the next is row percentage. The Site Type 1 with low densities of all materials is 45-DO-211, Zone 5 a zone with a comparatively low sampling percentage. It also crops up as an outrider in most other indices.

Table 6-5. Intersection of feature and density site types.

Feature Site Type	Density Site Type (grouped)								Total
	111		Two Low		Two High		222		
	N	%	N	%	N	%	N	%	
1	1	8.0	0	0.0	4	31.0	8	62.0	13
2	5	28.0	8	44.0	3	17.0	2	11.0	18
3	20	69.0	8	28.0	1	3.0	0	0.0	29

There is less difference between Type 2 and Type 3 sites in terms of the associated density values than there is between either of these and Type 1 sites. Nevertheless, there is a strong correlation between the two systems such that virtually the same pattern of site distribution in time and space probably could be obtained by using either system. The uncombined density site types would have to be grouped to provide large enough samples to detect patterning.

FUNCTIONAL TOOL CLASS PATTERNING

In examining the distribution of traditional tool classes among the project's analytic zones we hope to identify strong patterning in richness that correlates with both feature and density site types. We expect that central base site analogues (Feature Site Type 1; Density Site Types 222, 122, and 212) will show greatest richness, and were we to measure it, the most even distribution of functional class analogs. Field camp analogs (Feature Site Type 2; Density Site Types 112, 121, and 211) would show intermediate values of richness and evenness. Finally, location/station analogs (Feature Site Type 3 and Density Site Type 111) would display low richness and low evenness values.

There are other reasons for examining the traditional tool class distributions. We hope to see major qualitative differences in phase inventory particularly if differences pertain to different kinds of sites. If the patterns are pertinent to site function, the information may be of significant value in understanding changes in prehistoric human adaptation.

As our main inquiry here is into complexity of activity at each site, we have grouped the project's salvage assemblages of commonsense, traditional tool classes into rough functional class equivalents. We should note that the project has examined macroscopic evidence of tool use, finding that most of the traditional tool classes have use traces that are compatible with the function implied by their common sense names. On the other hand, the studies also have shown that the common sense classes sometimes do not go far enough in describing the use the object may have received, for many of the objects served multiple purposes. Gravers, for instance, always have edge damage that suggests use of a point to incise (scrape) hard materials, but very often they also have abruptly concave worn areas that almost certainly were used as spokeshaves to scrape hard materials. Not infrequently, auxiliary worn areas on objects such as projectile points suggest wear induced by hafting or by rubbing against quivers or other toolholders. Probably the most notable and frequent examples of complex multipurpose tools are cobble implements of the Kartar and Hudnut Phases, objects that often show several uses of quite distinct character (e.g. Lohse 1984; Miss 1984a and b).

In spite of occasional multipurpose uses, the traditional descriptors adequately characterize the functional complexity of different sites and help point the way to studies that might be undertaken using more refined data and analytical methods. At the very least they should afford us a preliminary understanding of the content and functional character of the three phases.

Loosely following Wylie (1975), we have selected five general activities and twelve functions under which to group traditionally named objects (Table 6-6). These comprise an economic activity complex. We have added another complex for aesthetic activities to group ceremonial usage, ornamentation, rock art, etc. Table D-5, Appendix D shows basic data on artifacts by analytic zones, including mixed zones excluded from further tabulations. Artifacts are grouped and tallied, except for objects that are also known or suspected as temporal or cultural diagnostics, which are listed by occurrence. To escape spurious functional complexity that might result from individual display of temporally dependent tool types, counts of all tools in a given function then were combined into 19 superclasses (Table 6-7).

FUNCTIONAL RICHNESS

To identify functional richness of each analytic zone, we simply counted the number of represented functional superclasses (Table 6-8). These data were compared with total excavated volumes for feature and site density types and the results compared with site type sampling biases (see Table 6-2). While functional richness correlates strongly with site types (Tables 6-9 and 6-10), it is impossible to tell conclusively whether the correlation is the result of sampling biases.

Because there is a correlation of functional tool diversity and density site types (which are less sensitive to sampling bias, though not immune), there probably is a relationship between tool richness and site function that could be examined using more refined methods.

Table 6-6. Object types and activity complexes.

Complex	Activity	Function[1]	Associated Object Types[2]
Economic	Abrading	Abrading ABR	Shaft abrader
		Milling MIL	Edge ground cobble, paintstone
	Cutting	Carving CAR	Utilized flake, blade, microblade
		Sawing SAW	Flaked long bone
	Penetration	Awling AWL	Awl, needle, shuttle
		Drilling DRI	Drill
		Projectile Impact PRI	Projectile point, bone point/harpoon (includes composite harpoon valve, composite harpoon head, valved point, barbed harpoon point, hook/leister barb unipoint, round cross-section bipoint, flat cross-section bipoint, pointed bone fragment)
	Percussion	Chopping CHO	Chopper, peripherally flaked cobble adze, chisel adze, wedge
		Flaking FLA	Debitage (includes waste flakes, resharpening flakes, biface, bifacially retouched flake, unifacially retouched flake, amorphously flaked object, flake off blade core, core, blade core), Antler flaker, antler billet
		Pounding POU	Hammerstone, maul, pestle, hopper mortar, milling stone, anvil stone
	Scraping	Hard Scraping HSC	Burin, burin spall, graver, spokeshave
		Soft Scraping SSC	Unifacially retouched flake, utilized bone fragment, scraper, tabular knife
	Weighting	Weighting WEI	Netsinker
Aesthetic	Decorating	Decorating DEC	Pipe, shell ornaments (includes dentalium, olivella, marginella, shell bead), Copper ornaments (rolled copper, other copper, copper needle/pin), Bone ornaments (includes bone bead/bead blank, pendant, handle), stone ornaments (includes beads, pendant, shaped/incised siltstone), ochre

1. Below each Function category is the three-letter abbreviation used in Tables 6-7, 6-11, and 6-12.
2. We use the traditional tool type names used in the project descriptive site reports (see Campbell 1984 for definitions), or indicate which ones are included in a more inclusive category, e.g. bone point/harpoon.

Table 6-7. Functional groupings of traditional types by site.

Site	Zone	Phase	Site Type		Vol m^3	Functional Categories[1]														Total	Density N/m^3
			Feat.	Dens.		ABR	MIL	CAR	SAW	AWL	DRI	PRI	CHO	FLA	POU	HSC	SSC	WEI	DEC		
45-DO-204	1	Coyote Creek	2	111	63.8	0	0	27	0	0	0	3	1	600	3	0	11	0	0	645	10.1
45-DO-204	2	Hudnut	3	111	32.3	0	0	42	0	0	1	3	1	1100	0	1	23	0	0	1171	18.4
45-DO-204	3	Kartar	3	111	25.5	1	0	52	0	0	1	1	10	1000	2	2	20	0	0	1089	17.1
45-DO-204	4	Kartar	3	111	32.2	0	0	10	0	0	0	1	0	200	0	0	0	0	0	211	3.3
45-DO-211	1	Historic	3	111	23.7	0	0	14	0	0	0	4	0	600	0	0	8	0	0	626	9.8
45-DO-211	2	Hudnut	3	122	26.4	0	0	24	0	0	0	7	0	1300	3	0	19	0	0	1353	21.2
45-DO-211	3	Hudnut	3	121	40.9	0	0	33	0	0	0	4	2	1500	2	0	13	0	1	1555	24.4
45-DO-211	4	Hudnut	1	222	33	0	0	23	0	0	0	9	5	1100	1	0	25	0	1	1164	18.2
45-DO-211	5	Hudnut	1	111	28.2	0	0	17	0	0	0	2	4	600	0	0	5	0	0	628	9.8
45-DO-214	1	Coyote Creek	2	111	63.3	0	0	116	0	2	0	35	2	3000	1	3	21	0	1	3181	49.9
45-DO-214	2	Coyote Creek	2	212	31.3	1	0	202	0	0	3	43	3	5400	4	3	51	0	3	5713	89.5
45-DO-214	3	Coyote Creek	2	211	33.3	8	0	209	0	6	0	52	2	5200	2	2	58	0	10	5549	87.0
45-DO-214	4	Hudnut	3	121	63.1	0	0	86	0	0	1	14	6	1900	4	0	53	0	1	2065	32.4
45-DO-242	1	Coyote Creek	2	112	30.5	1	0	26	0	0	2	22	1	900	1	0	31	0	3	987	15.5
45-DO-242	2	Coyote Creek	2	112	33	0	0	30	1	0	3	28	2	1500	6	3	32	0	2	1607	25.2
45-DO-242	3	Hudnut	1	212	69.7	0	0	75	5	2	5	53	4	4101	5	2	65	0	8	4325	67.8
45-DO-242	4	Kartar	3	111	20.3	0	0	1	1	0	0	0	0	100	0	0	1	0	1	104	1.6
45-DO-243	1	Coyote Creek	3	111	25.5	0	0	11	0	0	0	5	0	500	0	0	4	0	0	520	8.2
45-DO-243	2	Hudnut	2	111	23.3	0	0	17	0	0	1	4	1	800	0	0	22	0	0	845	13.2
45-DO-243	3	Hudnut	2	111	17.9	0	0	5	0	1	0	5	3	600	0	0	5	0	0	619	9.7
45-DO-243	4	Kartar	3	111	18.2	0	0	3	0	0	0	3	3	200	0	0	4	0	0	213	3.3
45-DO-273	1	Coyote Creek/ Kartar	3	111	43.1	0	0	38	0	0	0	6	1	400	2	0	8	0	0	455	7.1
45-DO-273	2	Coyote Creek	3	111	29.6	1	0	92	0	0	0	3	9	900	9	2	21	0	0	1037	16.3
45-DO-273	3	Kartar	3	111	37.7	0	0	172	0	0	2	8	7	1700	6	3	27	1	0	1926	30.2
45-DO-273	4	Kartar	3	111	28.8	0	0	28	0	0	2	3	0	200	0	1	2	0	0	236	3.7
45-DO-273	5	Kartar	3	111	19.4	0	0	7	0	0	0	1	1	100	2	0	1	0	0	112	1.8

1. See Table 6-6 for key to functional category abbreviations.

Table 6-7, cont'd.

Site	Zone	Phase	Site Type		Vol m^3	Functional Categories															Density N/m^3
			Feat.	Dens.		ABR	MIL	CAR	SAW	AWL	DRI	PRI	CHO	FLA	POU	HSC	SSC	WEI	DEC	Total	
45-DO-282	1	Kartar	3	111	45	0	0	138	0	0	0	2	0	701	0	1	13	0	0	855	13.4
45-DO-282	2	Kartar	3	111	40.7	0	0	117	0	0	2	6	0	1002	2	4	17	0	0	1150	18.0
45-DO-282	3	Kartar	3	111	53.1	0	0	220	0	0	2	4	5	1706	7	5	23	0	C	1972	30.9
45-DO-282	4	Kartar	3	111	47.3	0	0	70	0	0	2	3	0	400	2	2	6	0	0	485	7.6
45-DO-282	5	Mixed	3	NA		0	0	168	0	0	3	17	25	1304	7	0	40	0	0	1564	24.5
45-DO-285	1	Coyote Creek	3	112	52.9	0	0	157	0	0	2	44	3	11100	10	3	34	0	1	11354	178.0
45-DO-285	2	Coyote Creek	3	111	26.3	0	0	51	0	0	0	7	0	4300	0	1	11	0	0	4370	68.5
45-DO-285	3	Hudnut	3	112	29	0	0	109	0	0	4	28	1	1300	9	5	48	0	0	1504	23.6
45-DO-285	4	Hudnut	3	112	28.9	0	0	94	0	0	3	14	1	9500	2	1	34	0	0	9649	151.2
45-DO-326	1	Coyote Creek	2	212	25.4	0	0	52	2	0	1	28	1	1900	4	3	7	0	1	1999	31.3
45-DO-326	2	Coyote Creek	3	211	24.1	0	0	48	1	0	1	22	1	1701	8	2	6	0	0	1791	28.1
45-DO-326	3	Hudnut	2	212	12.5	0	0	102	1	0	1	15	2	1902	2	1	10	0	1	2037	31.9
45-DO-326	4	Hudnut/Kartar	3	211	30.6	0	0	96	1	0	4	8	2	1201	2	3	8	0	0	1325	20.8
45-OK-2	1	Coyote Creek	1	212	152.9	0	0	367	4	6	4	153	18	22400	17	7	213	2	25	23216	363.9
45-OK-2	2	Coyote Creek	1	222	131.5	0	1	289	13	13	4	107	7	17200	24	5	235	0	20	17918	280.8
45-OK-2	3	Hudnut	1	222	97.7	0	0	119	12	4	4	50	11	9200	21	4	164	0	20	9609	150.6
45-OK-2	4	Hudnut	2	222	84.7	0	0	45	12	6	0	18	3	2700	6	3	47	0	10	2850	44.7
45-OK-2A	1	Coyote Creek	2	112	21.3	0	0	24	0	0	1	17	1	1500	0	3	11	0	0	1557	24.4
45-OK-2A	2	Hudnut	1	212	21.2	0	0	13	0	0	0	2	2	700	2	0	13	0	0	732	11.5
45-OK-2A	3	Kartar	3	111	20.9	0	0	3	0	0	0	1	1	200	0	0	4	0	0	209	3.3
45-OK-2A	4	Kartar	3	111	16.1	0	0	0	0	0	0	0	0	100	1	1	1	0	0	103	1.6
45-OK-4	51	Coyote Creek	2	112	113.2	0	0	53	1	0	5	54	6	5300	5	7	75	0	1	5507	86.3
45-OK-4	52	Hudnut	1	222	93.2	0	0	74	4	3	4	85	9	11700	40	8	185	0	19	12131	190.1
45-OK-4	53	Hudnut/Kartar	3	121	37.2	0	0	9	0	0	0	10	3	1000	1	1	10	0	4	1038	16.3
45-OK-11	A	Hudnut	2	112	306.7	2	1	199	3	1	4	132	22	23200	43	18	157	1	8	23792	372.9
45-OK-11	B	Kartar	1	222	571.8	1	3	187	12	30	5	160	264	24107	97	11	227	2	23	25129	393.9

Table 6-7, cont'd.

Site	Zone	Phase	Site Type		Vol m3	Functional Categories														Total	Density N/m^3
			Feat.	Dens.		ABR	MIL	CAR	SAW	AWL	DRI	PRI	CHO	FLA	POU	HSC	SSC	WEI	DEC		
45-OK-18	1	Coyote Creek/ Hudnut	3	111	58.4	0	0	67	0	0	1	19	0	1700	3	0	37	0	37	1864	29.2
45-OK-18	2	Hudnut	2	111	59	0	0	181	0	0	2	28	0	3200	8	0	53	0	79	3551	55.7
45-OK-18	3	Hudnut	3	111	42.1	0	0	53	0	0	0	10	0	800	0	0	11	0	11	885	13.9
45-OK-18	4	Kartar	3	111	7.8	0	0	5	0	0	0	0	0	100	0	0	0	0	0	105	1.6
45-OK-250	51	Coyote Creek/ Hudnut	2	222	137.9	0	1	116	1	0	3	58	6	6200	19	1	149	0	30	6584	103.2
45-OK-250	52	Hudnut	1	222	155.6	0	0	194	20	3	12	81	13	10000	47	5	182	0	37	10594	166.1
45-OK-250	53	Hudnut/Kartar	2	121	79.9	0	0	114	0	0	1	7	0	600	2	0	13	0	2	739	11.6
45-OK-258	A	Coyote Creek	1	222	164.6	0	2	318	0	0	12	155	13	17500	37	18	160	0	6	18221	285.6
45-OK-258	B	Hudnut	1	222	200.9	0	3	262	0	0	10	134	23	18100	72	9	201	0	15	18829	295.1
45-OK-287/8	1	Coyote Creek	3	111	19.7	0	0	2	0	0	0	0	1	100	1	0	2	0	0	106	1.7
45-OK-287/8	2	Coyote Creek	2	112	46.3	0	0	18	0	0	0	6	3	400	4	2	8	0	0	441	6.9
45-OK-287/8	3	Coyote Creek	1	212	54.7	0	0	59	5	0	0	20	6	1800	6	1	46	0	0	1943	30.5
45-OK-287/8	4	Coyote Creek/ Hudnut/Kartar	2	112	41.1	0	1	57	0	1	0	14	14	1500	6	0	38	0	1	1632	25.6
45-OK-287/8	5	Coyote Creek/ Hudnut/Kartar	2	212	47.1	0	0	63	12	1	0	11	8	2900	19	6	58	0	0	3078	48.2
45-OK-287/8	6	Kartar	2	112	35.6	0	0	29	2	0	0	4	59	1800	24	2	22	0	1	1943	30.5
		Total			4129	15	12	5703	113	79	118	1853	602	259525	613	166	3109	6	383	272297	65.9

Volume in cubic meters.

Density in number of objects per cubic meter.

See text for definition of feature and density site types.

Table 6-8. Artifact diversity compared with volume and site type.

Site	Zone	Phase	Site Type		Function		Volume
			Feat.	Dens.	Density	Count	
45-OK-18	4	Karter	3	111	1.6	2	7.8
45-OO-204	4	Karter	3	111	3.3	3	32.2
45-OK-2A	4	Karter	3	111	1.6	4	16.1
45-OO-243	1	Coyote Creek	3	111	8.2	4	25.5
45-OO-282	1	Karter	3	111	13.4	5	45
45-OO-243	4	Karter	3	111	3.3	5	18.2
45-OK-287/8	1	Coyote Creek	3	111	1.7	5	19.7
45-OO-242	4	Karter	3	111	1.8	5	20.3
45-OK-2A	3	Karter	3	111	3.3	5	20.9
45-OO-285	2	Coyote Creek	3	111	68.5	5	26.3
45-OO-211	2	Hudnut	3	122	21.2	5	26.4
45-OO-211	5	Hudnut	1	111	8.8	5	28.2
45-OK-18	3	Hudnut	3	111	13.9	5	42.1
45-OO-243	3	Hudnut	2	111	9.7	6	17.9
45-OO-273	5	Karter	3	111	1.8	6	19.4
45-OK-2A	2	Hudnut	1	212	11.5	6	21.2
45-OO-243	2	Hudnut	2	111	13.2	6	23.3
45-OO-273	4	Karter	3	111	3.7	6	28.8
45-OO-204	2	Hudnut	3	111	18.4	6	32.3
45-OO-211	4	Hudnut	1	222	18.2	7	33
45-OK-18	2	Hudnut	2	111	55.7	7	59
45-OK-2A	1	Coyote Creek	2	112	24.4	7	21.3
45-OO-282	2	Karter	3	111	18.0	7	40.7
45-OO-211	3	Hudnut	3	121	24.4	7	40.9
45-OK-287/8	2	Coyote Creek	2	112	6.9	7	46.3
45-OO-282	4	Karter	3	111	7.6	7	47.3
45-OO-204	1	Coyote Creek	2	111	10.1	7	63.8
45-OO-285	3	Hudnut	3	112	23.6	8	29
45-OO-285	4	Hudnut	3	112	151.2	8	28.9
45-OO-273	2	Coyote Creek	3	111	16.3	8	29.6
45-OO-282	3	Karter	3	111	30.9	8	53.1
45-OK-287/8	3	Coyote Creek	1	212	30.5	8	54.7
45-OO-214	4	Hudnut	3	121	32.4	8	63.1
45-OO-328	2	Coyote Creek	3	211	28.1	9	24.1
45-OO-204	3	Karter	3	111	17.1	9	25.5
45-OO-242	1	Coyote Creek	2	112	15.5	9	30.5
45-OO-328	4	Karter*	3	211	20.8	9	30.6
45-OK-287/8	6	Karter	2	112	30.5	9	35.6
45-OO-273	3	Karter	3	111	30.2	9	37.7
45-OO-285	1	Coyote Creek	3	112	178.0	9	52.9
45-OO-214	1	Coyote Creek	2	111	49.9	9	63.3
45-OO-242	2	Coyote Creek	2	112	25.2	10	33
45-OO-328	3	Hudnut	2	212	31.9	10	12.5
45-OO-328	1	Coyote Creek	2	212	31.3	10	25.4
45-OO-214	2	Coyote Creek	2	212	89.5	10	31.3
45-OO-214	3	Coyote Creek	2	211	87.0	10	33.3
45-OK-2	4	Hudnut	2	222	44.7	10	84.7
45-OK-4	51	Coyote Creek	2	112	88.3	10	113.2
45-OK-258	A	Coyote Creek	1	222	285.6	10	184.6
45-OK-258	B	Hudnut	1	222	295.1	10	200.9
45-OO-242	3	Hudnut	1	212	67.8	11	69.7
45-OK-4	52	Hudnut	1	222	190.1	11	93.2
45-OK-2	3	Hudnut	1	222	150.8	11	97.7
45-OK-250	51	Coyote Creek*	2	222	103.2	11	137.9
45-OK-250	52	Hudnut	1	222	188.1	11	155.6
45-OK-2	2	Coyote Creek	1	222	280.8	12	131.5
45-OK-2	1	Coyote Creek	1	212	383.9	12	152.9
45-OK-11	A	Hudnut	2	112	372.9	14	308.7
45-OK-11	B	Karter	1	222	393.9	14	571.8

Table 6-9. Functional richness by feature site type.

Feature Site Type	Number of Functional Classes								Total
	2-5		6-8		9-10		11-14		
	N[1]	%	N	%	N	%	N	%	
1	1	8.0	3	23.0	0	0.0	9	62.0	13
2	0	0.0	6	33.0	10	56.0	2	11.0	18
3	12	43.0	11	39.0	5	18.0	0	0.0	28

1. N = number of components.

Table 6-10. Functional richness by density site type.

Density Site Type	Number of Functional Classes								Total
	2-5		6-8		9-10		11-14		
	N[1]	%	N	%	N	%	N	%	
111	12	46.0	11	42.0	3	12.0	0	0.0	26
2 Low	0	0.0	6	40.0	8	53.0	1	7.0	15
2 High	1	12.0	2	25.0	3	38.0	2	25.0	8
222	0	0.0	1	10.0	1	10.0	8	80.0	10

1. N = number of components.

FUNCTIONAL VARIATION

The surrogate functional classes offered by the traditional tool classes suggest several interesting patterns that may represent real functional differences among site types. Unfortunately, small numbers usually will restrict our observations to the realm of speculation and suggestions for further investigation. Tables 6-11 and 6-12 present the counts and percentages of functional superclasses by phase and feature site type.

Functional Characteristics of Feature Site Types

If we look at the total site type inventory which combines data from all phases in Table 6-12 there appear to be significant differences among the site types with respect to functional tool inventory. While the present examination is limited to the somewhat imprecise traditional tool class inventory, the results suggest that a more careful examination using the more detailed functional data that is available and a selected series of analytic zones would be worthwhile to shed further light on the nature of the differences.

Table 6-11. Artifact distribution by phase and site types (counts).

Phase	Site Type	Functional Category[1]														Totals	Volume
		ABR	MIL	CAR	SAW	AWL	DRI	PRI	CHO	FLA	POU	HSC	SSC	WEI	DEC		
Coyote Creek	1	0	3	1033	22	19	20	435	44	58900	84	31	654	2	51	61298	503.7
	2	10	1	873	5	8	18	346	28	31900	49	27	454	0	51	33770	599.3
	3	1	0	362	1	0	3	81	14	18601	28	8	78	0	1	19178	178.1
	All	11	4	2268	28	27	41	862	86	109401	161	66	1186	2	103	114246	1281.1
Hudnut	1	0	3	777	41	12	35	416	71	55501	188	28	840	0	100	58012	699.5
	2	2	1	549	16	8	8	202	31	32402	59	23	294	1	98	33694	504.1
	3	0	0	441	0	0	9	80	11	17400	20	7	201	0	13	18182	262.7
	All	2	4	1767	57	20	52	698	113	105303	267	58	1335	1	211	109888	1466.3
Kartar	1	1	3	187	12	30	5	160	264	24107	97	11	227	2	23	25129	571.8
	2	0	0	29	2	0	0	4	59	1800	24	2	22	0	1	1943	35.6
	3	1	0	922	2	0	15	41	29	8910	24	22	127	1	1	10095	443.6
	All	2	3	1138	16	30	20	205	352	34817	145	35	376	3	25	37167	1051
Sum	1	1	9	1997	75	61	60	1011	379	138508	369	70	1721	4	174	144439	1775
	2	12	2	1451	23	16	26	552	118	66102	132	52	770	1	150	69407	1139
	3	2	0	1725	3	0	27	202	54	44911	72	37	406	1	15	47455	884.4
	All	15	11	5173	101	77	113	1765	551	249521	573	159	2897	6	339	261301	3798.4

See Table 6-6 for key to functional category abbreviations.

Table 6-12. Artifact distribution by phase and site type (percentage).

Phase	Site Type	Functional Category[1] (% of Total)														Vol
		ABR	MIL	CAR	SAW	AWL	DRI	PRI	CHO	FLA	POU	HSC	SSC	WEI	DEC	
Coyote Creek	1		0.005	1.685	0.036	0.031	0.033	0.710	0.072	96.1	0.137	0.051	1.067	0.003	0.083	504
	2	0.030	0.003	2.585	0.015	0.024	0.053	1.025	0.083	94.5	0.145	0.080	1.344		0.151	599
	3	0.005		1.888	0.005		0.016	0.422	0.073	97.0	0.146	0.042	0.407		0.005	178
	All	0.010	0.004	1.985	0.025	0.024	0.036	0.755	0.075	95.8	0.141	0.058	1.038	0.002	0.090	1281
Hudnut	1		0.005	1.339	0.071	0.021	0.060	0.717	0.122	95.7	0.324	0.048	1.448		0.172	699
	2	0.006	0.003	1.628	0.047	0.024	0.024	0.600	0.092	96.2	0.175	0.068	0.873	0.003	0.281	504
	3			2.425			0.049	0.440	0.060	95.7	0.110	0.038	1.105		0.071	263
	All	0.002	0.004	1.608	0.052	0.018	0.047	0.635	0.103	95.8	0.243	0.053	1.215	0.001	0.192	1466
Kartar	1	0.004	0.012	0.744	0.048	0.119	0.020	0.637	1.051	95.9	0.386	0.044	0.903	0.008	0.092	572
	2			1.493	0.103			0.206	3.037	92.6	1.235	0.103	1.132		0.051	36
	3	0.010		9.133	0.020		0.149	0.406	0.287	88.3	0.238	0.218	1.258	0.010	0.010	444
	All	0.005	0.008	3.062	0.043	0.081	0.054	0.552	0.947	93.7	0.390	0.094	1.012	0.008	0.067	1051
Sum	1	0.001	0.006	1.383	0.052	0.042	0.042	0.700	0.262	95.9	0.255	0.048	1.192	0.003	0.120	1775
	2	0.017	0.003	2.091	0.033	0.023	0.037	0.795	0.170	95.2	0.190	0.075	1.109	0.001	0.216	1139
	3	0.004		3.635	0.006		0.057	0.426	0.114	94.6	0.152	0.078	0.856	0.002	0.032	884
	All	0.006	0.004	1.980	0.039	0.029	0.043	0.675	0.211	95.5	0.219	0.061	1.109	0.002	0.130	3798

1. See Table 6-6 for key to functional category abbreviations.

One of the most interesting differences among the three site types resides in those categories dominated by large stone tools such as choppers, mauls/pestles, and hopper mortar/milling stones etc. As many of these tools are thought to be used in final consumption activities, it is not unexpected that they tend to be represented in highest proportion in Type 1 (central base camp surrogate) sites. Part of the association doubtless is temporal, as large cobble implements are most characteristic of the Kartar Phase, and the site at which they are most frequent is a Type 1. It is likely that the multipurpose, heavily used cobble implements of this phase performed functions that later were assumed by other kinds of implements, explaining the changes in functional group percentages noted in Table 6-12.

Two categories, flaking and soft scraping, show a narrow but significant range of differentiation among site types. Flaking is linked to the basic reductional technology of stone tool production, and as stone tools are used and produced at all sites, it is not surprising that a relatively constant proportion of debitage is present. In spite of the large-scale regularity, there is a difference among the sites; as the difference occurs in a category with very large representation, it is likely to be significant. Site Type 1 has the greatest proportional representation of the flaking category and Site Type 3 the least, which is what one would expect (see Leeds et al. Chapter 1; Chatters 1984a). Soft scraping (members of the class usually are quartzite tabular tools) is another very interesting category with fairly large membership and a narrow but consistent degree of differences among the site types. Type 1 and 2 sites are most alike and have the greatest representation; Type 3 falls outside (below) the typical values of the former. As these kinds of implements are well represented in all phases, the difference is not likely to be temporal.

Some other classes that show consistent differences among site types but which have small membership are awling, sawing, and hard scraping. Unexpected differences occur in the abrading, drilling, and decorating classes, but vagaries of sampling probably are responsible as the numbers are very low.

What appear to be anomalies on first inspection occur in trends in carving (utilized flakes) and projectile impact. However, the former may reflect greater emphasis on curated tool forms in central bases and field camps. Projectile impact is somewhat harder to explain, but may result from greatest concern with maintenance and production of weaponry in field camps and central base camps.

Functional Characteristics of Feature Site Types by Phase

Feature Site Type 1's differ little through time except in poorly represented categories and in the previously mentioned cobble tool classes (Table 6-12). Among Feature Site Type 2, only the Hudnut and Coyote Creek phases may safely be compared, as this type is scarcely represented in the Kartar Phase. There are no significant differences between the two phases. Perhaps the most intriguing differences show up in the phase comparison of Site Type 3. While there is enough sampling differential to make observations tentative, the Kartar Phase Type 3 sites differ from those of the later phases in ways that cannot be ascribed to the change from cobble to flake utility tools, primarily in higher proportions of carving, sawing, drilling, and hard and soft scraping. This difference supports a contention that the Kartar Phase's economic adaptation differed from that of the later phases.

PATTERNING OF FAUNAL REMAINS

The final check on the usefulness of the feature site types is their associated faunal diversity and characteristics. We assume that different kinds of sites should have significant differences in their faunal assemblages. Following Chatters (1984a), we expect that in a collecting system, base camps (Feature Site Type 1) would show medium richness and low to moderate evenness resulting from emphasis on stored species or economies of scale. Field camps (Site Type 2) in a strongly logistical system would show somewhat greater richness and higher evenness due to the intensive taking of storage species, siting in locations favoring a variety of subsistence species but focusing on economy of scale, and use of local fauna for day-to-day subsistence. Finally, we expect locations/stations (Site Type 3) in a strongly logistical system to have the least richness and the least evenness, due to concentration on economy of scale and siting in locations strongly favoring species comprising the scale economy.

To investigate the richness and evenness characteristics of each kind of site, we assembled data on what we assume to be the economically important faunal remains from chronologically pure analytic zones (source data is in Table D-6, Appendix D). We tabulated counts of number of identifiable specimens (NISP) for each site type by phase and riverbank, dropping amphibian, reptilian, and mammalian microfauna and lumping counts for the highly diverse array of carnivores (see Livingston, Chapter 12, for a discussion of the merits of NISP vs. MNI for this purpose). We divided fish into salmonid and non-salmonid and summed NISP. Freshwater mussel shell counts were taken only from those sites or zones where measurement procedures resulted in roughly comparable data (Campbell 1984b).

Assemblages first were compared with respect to mammalian taxa frequencies as percentages of total mammalian NISP count by phase and site type; fish taxa frequencies as percentages of total fish NISP count; and density figures (number per cubic meter) for turtle NISP and freshwater mussel shell hinge count. Mammalian and fish taxa distributions were compared separately due to the potential for differences in preservation between the two groups and to highlight any changes in emphasis among fish taxa. Of the other vertebrates we chose to examine turtle alone; because we could not compare relative proportions we used density as the most appropriate measure of comparison among assemblages. We used density for mussels for the same reason. Biases in density data due to differential deposition rates probably are inconsequential (Miss, Chapter 9). The categories were tabulated by riverbank, phase, and site type (Table 6-13), and by phase and site type (Tables 6-14 and 6-15). Because the small sample size of some taxonomic

Table 6-13. Distribution of faunal remains by riverbank, phase, and site type.

Bank	Phase	Site Type	Mammals (%NISP)[1]													Fish (%NISP)		Reptiles (N/m³)	Mollusks (N/m³)	Sample Size	
			Small Herbivores						Large Herbivores						Carnivores						
			Lep	Syl	Mar	Cas	Ond	Eri	Equ	Cer	Odo	Ant	Ovi	Bis		Salmon	Other	Turtle	Shell[2]	m³	Zones
North	Coyote Creek	1	–	–	1.0	0.1	–	T[3]	0.8	0.2	83.3	2.3	11.0	–	1.3	89.0	11.0	0.139	68.3	504	4
		2	0.3	–	1.6	–	–	1.0	–	–	84.5	3.6	8.1	–	1.0	87.2	12.8	0.304	59.4	319	4
		3	–	–	–	–	–	–	–	–	100.0	–	–	–	–	–	–	–	–	20	1
		All	T	–	1.1	0.1	–	0.1	0.7	0.2	83.4	2.4	10.8	–	1.2	88.7	11.3	0.198	63.3	842	9
	Hudnut	1	0.1	T	0.5	0.1	–	–	–	0.5	83.1	0.5	10.2	–	5.0	93.5	6.5	0.552	209.9	569	5
		2	0.7	–	7.0	0.6	–	0.7	–	2.8	79.0	1.2	5.1	0.2	2.7	52.7	47.3	0.322	77.7	450	3
		3	–	–	–	–	–	–	–	–	–	–	–	–	–	100.0	–	0.024	0.1	42	1
		All	0.2	T	1.7	0.2	–	0.1	–	0.9	82.3	0.8	9.2	T	4.6	84.0	16.0	0.434	145.5	1061	9
	Karter	1	0.6		11.3	0.4	T	3.0		1.1	63.5	2.5	14.9	0.4	2.2	34.6	65.4	0.579	323.6	572	1
		2	–	–	–	–	–	–	–	–	–	–	–	–	–	100.0	–	–	0.6	36	1
		3	–	–	33.3	–	–	–	–	-	66.7	–	–	–	–	98.9	1.1	0.089	2.1	45	3
		All	0.6	–	11.2	0.4	0.1	3.0	–	1.0	63.6	2.5	14.9	0.4	2.2	41.3	58.7	0.514	283.9	652	5
	All	1	0.2	–	3.2	0.2	–	0.7	0.3	0.5	78.6	1.6	11.5	0.1	3.0	70.3	29.7	0.435	206.0	1644	10
		2	0.6	–	5.5	0.4	0.1	0.7	–	2.0	80.1	1.9	6.4	0.2	2.2	56.9	43.1	0.301	67.0	805	8
		3	–	–	37.5	–	–	–	–	–	62.5	–	–	–	–	98.9	1.1	0.047	0.9	107	5
		All	0.2	–	3.5	0.2	T	0.7	0.2	0.7	78.8	1.6	11.0	0.1	2.9	69.4	30.6	0.376	153.7	2555	23
South	Coyote Creek	2	1.0	2.2	9.1	0.2	0.2	–	–	0.5	62.0	9.1	13.0	0.5	2.2	86.3	13.7	0.770	11.7	281	7
		3	0.5	2.2	27.3	–	–	–	–	3.8	25.7	15.3	22.4	–	2.7	95.1	4.9	0.101	0.1	158	5
		All	0.8	2.2	14.7	0.2	0.2	–	–	1.5	50.9	11.0	15.9	0.3	2.3	88.3	11.7	0.528	7.5	439	12
	Hudnut	1	0.2	0.3	5.5	0.5	–	–	–	0.6	57.4	0.3	30.7	–	4.4	99.1	0.9	0.435	43.9	131	3
		2	–	–	58.8	–	–	–	–	–	28.9	2.1	10.3	–	–	100.0	–	0.083	22.4	54	3
		3	1.4	–	43.4	2.4	–	–	–	7.5	29.2	–	6.6	6.1	3.3	99.4	0.6	0.159	65.0	221	6
		All	0.4	0.2	19.7	0.9	–	–	–	2.2	48.0	0.4	23.1	1.4	3.7	99.2	0.8	0.239	52.5	405	12
	Karter	3 (All)	0.4	1.6	50.6	–	–	–	–	0.8	15.8	0.4	6.5	–	23.9	100.0	–	0.065	0.4	399	12
	All	1	0.2	0.3	5.5	0.5	–	–	–	0.6	57.4	0.3	30.7	–	4.4	99.1	0.9	0.435	43.9	131	3
		2	0.8	1.8	18.5	0.2	0.2	–	–	0.4	55.8	7.8	12.5	0.4	1.8	88.0	12.0	0.661	13.4	334	10
		3	0.8	1.2	41.6	0.6	–	–	–	3.9	23.1	4.5	11.1	2.0	11.1	98.6	1.4	0.099	18.6	778	23
		All	0.6	1.1	22.3	0.5	0.1	–	–	1.7	44.5	4.0	18.3	0.8	6.0	96.7	3.3	0.286	19.9	1243	36

1. Small Herbivores: Lep=*Lepus*; Syl=*Sylvilagus*; Mar=*Marmota*; Cas=*Castor*; Ond=*Ondatra*; Eri=*Erithizon*;
   Large Herbivores: Equ=*Equus*; Cer=*Cervus*; Odo=*Odocoileus*; Ant=*Antilocapra*; Ovis=*Ovis*; Bis=*Bison*
2. Shell densities incorporate non-comparable data from 45-OK-4.
3. T = <0.1%.

Table 6-14. Faunal distribution by site type (counts).

Phase	Site	Mammals[1]													Fish		Density[2] N/Cubic m		Sampling Error	
		Herbivores												Carnivores						
		Small						Large												
		Lep	Syl	Mar	Cas	Ond	Eri	Equ	Car	Odo	Ant	Ovi	Bis		Salmon	Other	Turtle	Shell	Volume	AZ
Coyote Creek	1	0	0	35	5	0	1	27	8	2877	78	380	0	44	202	25	70	34387	503.7	4
	2	5	9	43	1	1	3	0	2	519	49	79	2	12	280	44	313	22211	599.3	11
	3	1	4	50	0	0	0	0	7	48	28	41	0	5	77	4	16	14	178.1	6
	All	6	13	128	6	1	4	27	17	3444	155	500	2	61	559	73	399	56612	1281.1	21
Hudnut	1	5	3	53	9	0	0	0	24	3708	23	600	0	229	1890	76	371	125103	699.5	8
	2	6	0	120	5	0	6	0	25	735	13	56	2	24	207	150	150	36189	504.1	6
	3	3	0	93	5	0	0	0	16	62	0	14	13	7	180	1	36	14347	262.7	7
	All	14	3	266	19	0	6	0	65	4505	36	670	15	260	2277	227	557	175639	1466.3	21
Karter	1	14	0	255	9	1	68	0	24	1432	56	335	10	50	276	522	331	185014	571.8	1
	2	0	0	0	0	1	0	0	0	26	2	8	0	0	4	0	0	21	35.6	1
	3	1	4	127	0	0	0	0	2	43	1	16	0	59	181	1	30	238	443.6	15
	All	15	4	382	9	2	68	0	26	1501	59	359	10	109	461	523	361	185273	1051	17
All	1	19	3	343	23	1	69	27	56	8017	157	1315	10	323	2368	623	772	344504	1775	13
	2	11	9	163	6	2	9	0	27	1280	64	143	4	36	491	194	463	58421	1139	18
	3	5	8	270	5	0	0	0	25	153	29	71	13	71	438	6	82	14599	884.4	28
	All	35	20	776	34	3	78	27	108	9450	250	1529	27	430	3297	823	1317	417524	3798.4	59

1. Small Herbivores: Lep=*Lepus*; Syl=*Sylvilagus*; Mar=*Marmota*; Cas=*Castor*; Ond=*Ondatra*; Eri=*Erithizon*;
   Large Herbivores: Equ=*Equus*; Car=*Cervus*; Odo=*Odocoileus*; Ant=*Antilocapra*; Ovis=*Ovis*; Bis=*Bison*
2. Shell densities incorporate non-comparable data from 45-OK-4.

Table 6-15. Faunal distribution by site type (percentage NISP).

Phase	Site Type	Mammals (%NISP)[1]													Fish (%NISP)		Reptiles (N/m³)	Molluscs (N/m³)	Sample Size	
		Small Herbivores						Large Herbivores						Carnivores						
		Lep	Syl	Mar	Cas	Ond	Eri	Equ	Car	Odo	Ant	Ovi	Bis		Salmon	Other	Turtle	Shell[2]	m³	Zones
Coyote Creek	1	-	-	1.0	0.1	-	-	0.8	0.2	83.3	2.3	11.0	-	1.3	89.0	11.0	0.139	68.3	504	4
	2	0.7	1.2	5.9	0.1	0.1	0.4	-	0.3	71.8	6.8	10.9	0.3	1.7	86.0	14.0	0.522	46.0	599	11
	3	0.5	2.2	27.2	-	-	-	-	3.8	26.1	15.2	22.3	-	2.7	95.0	5.0	0.090	0.1	178	6
	All	0.1	0.3	2.9	0.1	-	0.1	0.6	0.4	78.8	3.6	11.5	-	1.4	88.0	12.0	0.311	48.0	1281	21
Hudnut	1	0.1	0.1	1.1	0.2	-	-	-	0.5	79.7	0.5	12.9	-	4.9	96.0	4.0	0.530	278.0	700	8
	2	0.6	-	12.1	0.5	-	0.6	-	2.5	74.1	1.3	5.6	0.2	2.4	58.0	42.0	0.298	71.8	504	6
	3	1.4	-	43.7	2.3	-	-	-	7.5	29.1	-	6.6	6.1	3.3	99.0	1.0	0.137	54.6	263	7
	All	0.2	0.1	4.5	0.3	-	0.1	-	1.1	76.9	0.6	11.4	0.3	4.4	91.0	9.0	0.380	144.0	1466	21
Karter	1	0.6	-	11.3	0.4	-	3.0	-	1.1	63.5	2.5	14.9	0.4	2.2	35.0	65.0	0.579	323.6	572	1
	2	-	-	-	-	2.7	-	-	-	70.3	5.4	21.6	-	-	100.0	-	-	0.6	36	1
	3	0.4	1.6	50.2	-	-	-	-	0.8	17.0	0.4	6.3	-	23.3	99.0	1.0	0.068	0.5	444	15
	All	0.6	0.2	15.0	0.4	0.1	2.7	-	1.0	59.0	2.3	14.1	0.4	4.3	47.0	53.0	0.343	176.3	1051	17
All	1	0.2	-	3.3	0.2	-	0.7	0.3	0.5	77.4	1.5	12.7	-	3.1	79.0	21.0	0.435	226.0	1775	13
	2	0.6	0.5	9.3	0.3	0.1	0.5	-	1.5	73.0	3.6	8.2	0.2	2.1	72.0	28.0	0.406	57.0	1139	18
	3	0.8	1.2	41.5	0.8	-	-	-	3.8	23.5	4.5	10.9	2.0	10.9	99.0	1.0	0.093	16.5	884	28
	All	0.3	0.2	6.1	0.3	-	0.6	0.2	0.8	74.0	2.0	1.2	0.2	3.4	80.0	20.0	0.347	122.0	3798	59

1. Small Herbivores: Lep=Lepus; Syl=Sylvilagus; Mar=Marmota; Cas=Castor; Ond=Ondatra; Eri=Erithizon;
   Large Herbivores: Equ=Equus; Car=Cervus; Odo=Odocoileus; Ant=Antilocapra; Ovi=Ovis; Bis=Bison
2. Shell densities incorporate non-comparable data from 45-OK-2, but excludes non-comparable data from 45-OK-4.
3. T = <0.1%.

groups obscured broader exploitation trends, we also grouped the small and large herbivorous mammals (Table 6-16) and treated them in a single closed array with the other vertebrate economic taxa (carnivorous mammals, turtle, salmonid fish, and nonsalmonid fish).

TAXONOMIC RICHNESS

We derived mean richness for each site type (Table 6-17) by counting the represented taxa in Table 6-15.

Table 6-17. Taxonomic richness by phase and site type.

Phase	Feature Site Type	# of Taxa	Sampling Intensity		
			Total Volume (m^3)	Number of Analytic Zones	Average Volume/ Zone (m^3)
Coyote Creek	1	12	504	4	63
	2	16	599	11	54
	3	11	178	6	30
Hudnut	1	13	700	8	88
	2	14	504	6	84
	3	12	263	7	38
Kartar	1	14	572	1	572
	2	6	36	1	36
	3	12	444	15	30
All (mean)[1]	1	13	1204	12	100
	2	15	1103	17	61
	3	11.7	884	28	32

1. Kartar zones excluded from volume and zone figures, sample size not comparable.

It can be seen that the richness indices for the various site types fall within expectations previously discussed and cannot entirely be laid at the door of sampling deficiencies. Quite frankly, the correlation is somewhat surprising. We cannot rule out the effects of entropy with respect to the low richness of the Type 3 sites, as so many (53 percent) are from the older Kartar Phase. However, even in that phase the richness averages 12, a very high average value, so it is not likely that the low richness stems from the effects of entropy.

TAXONOMIC DISTRIBUTION

Rather than examine simply faunal evenness, we decided to explore the topic of faunal distributions from a number of different viewpoints, beginning with an examination of the distribution of fauna among the three feature site types. Echoing Livingston (Chapter 12) we emphasize that we regard the faunal data as among the most treacherous to interpret due to perishability and cultural selection, and caution the reader to see these investigations as preliminary and aimed at finding only the most strongly expressed distributional trends.

Table 6-16. Distribution of fauna by major groups (percentage NISP).

Phase	Site Type	Mammals			Reptile	Fish		Mollusks	Sampling Error	
		Herbivore		Carni-vores						
		Small	Large		Turtle	Salmonid	Other	Shell	Volume	Zones
Coyote Creek	1	1.09	89.82	1.17	1.87	5.38	0.67	68.0	504	4
	2	4.55	47.80	0.88	22.98	20.56	3.23	46.0	599	11
	3	19.57	44.13	1.78	5.69	27.40	1.42	0.1	178	6
	All	2.93	76.83	1.13	7.40	10.36	1.35	48.0	1281	21
Hudnut	1	1.00	62.29	3.28	5.31	27.03	1.09	278.0	699	8
	2	9.14	55.44	1.60	10.01	13.81	10.01	72.0	504	6
	3	23.49	24.42	1.63	8.37	41.86	0.23	54.6	263	7
	All	3.45	59.32	2.91	6.24	25.53	2.54	144.0	1466	21
Karter	1	10.26	54.89	1.48	9.78	8.16	15.43	323.6	572	1
	2	2.44	87.80			9.76		0.6	36	1
	3	28.39	13.33	12.69	6.45	38.92	0.22	0.5	444	15
	All	12.34	50.27	2.80	9.28	11.85	13.45	176.3	1051	17
All	1	3.24	67.83	2.29	5.47	16.76	4.41	228.0	1775	13
	2	6.89	52.31	1.24	15.95	16.92	6.69	57.0	1139	18
	3	24.49	24.74	6.04	6.97	37.24	0.51	16.5	884	28
	All	5.20	62.57	2.36	7.23	18.11	4.52	122.0	3798	59

Note: Shell counts for analytic zones at 45-OK-4 omitted; vertebrates expressed as a percentage of total vertebrate NISP count, less non-economic microfauna; mollusks expressed as density (number per cubic meter)

Taxonomic Distribution by Site Type

It is evident that, from the standpoint of their faunal components, the feature site types represent different phenomena (Tables 6-15 and 6-16).

Site Type 1 is characterized by the highest proportions of large herbivores and highest densities of shell, and the lowest proportions of small herbivores, turtle and fish of both types (Table 6-16). Conversely, Site Type 3 is characterized by the lowest proportions of large herbivores and the lowest densities of shell, and the highest proportions of small herbivores, carnivores, and salmonid fish. The proportions of large herbivores, small herbivores, carnivores, salmonid fish and nonsalmonid fish at Site Type 2 are closer to those of Type 1 than Type 3, but Type 2 is distinguished by having the highest values of turtle and much lower densities of shellfish than are found at Type 1 sites.

When we look at the constituent taxa (Table 6-15), we see some variance from the larger trends. For example, while large herbivores are most prominent at Type 1 sites, this trend is determined almost entirely by the trend of deer, the most abundant ungulate in the assemblage; the distribution of other ungulates may be quite different. Like deer, both horse and mountain sheep (the second most abundant ungulate taxon) are most common at Type 1 sites. However, bison, antelope, and elk are all found in highest proportions at Type 3 sites. The high relative frequency of small herbivores at Type 3 sites is determined largely by the trend in marmots, the most abundant of the constituent taxa, although the trend is true of hares, rabbits, and beaver as well. River otter, on the other hand, has been found only at Type 2 sites, and porcupine remains are most common at Type 1 sites.

Chronological Trends in Site Type Faunal Assemblages

Many of the general trends discussed above hold true when the site types are considered by phase, but other significant trends emerge as well. As there are inevitably troubles resulting from smaller sample sizes, we look at only the most general changes and kinds of association.

In all phases, we find the greatest density of shellfish at Type 1 sites and the least at Type 3 sites, although there is a radical decrease in shell density in the Coyote Creek Phase at Type 1 sites and overall. The very low amounts of shell may in part result from the way this site type is defined as dense areas of shell were generally treated as features during excavation. The proportional emphasis on salmon is surprisingly strong at Type 3 sites in all phases. The relative importance of nonsalmonid fish is greatest at Type 2 sites in both the Hudnut and Coyote Creek Phases. The Kartar Phase is distinct in having higher relative proportions of nonsalmonid fish than are found in any other site type and phase. Given that the greatest abundances of shell, which would tend to preserve small bones through calcium ion exchange, occur at Type 1 sites, it would be difficult to argue that the patterns of salmonid or nonsalmonid fish abundances are due to differential preservation.

The overall proportion of turtle does not vary much among the phases and the highest proportions are found at Type 2 sites in both the Coyote Creek and Hudnut Phases; they are lacking from the noncomparable Kartar Phase sample.

The pattern described above, in which large herbivores are most common at Type 1 sites and least common at Type 3 sites, with a reversed trend for small herbivores, generally holds. In the Kartar Phase, the highest proportions of large herbivores and lowest proportions of small herbivores are found at Site Type 2; however because the sample consists of but a small volume from a single zone, sampling bias may be the cause. Although the ordinal relationship among the site types is relatively constant, there is an increase in the relative proportions of large herbivores through time at each site type, and a corresponding decrease in the the proportions of small herbivores.

Even though the overall proportions of marmots in the phase assemblages decreases through time, marmots are always found in the same ordinal pattern--highest proportions at Type 3 sites and lowest at Type 1 sites. As this species was an early spring to early summer food resource in ethnohistoric times (Bouchard 1985; Ray 1932); its association with Site Type 3 is supporting evidence for type's utility as a location/station surrogate.

Overall, the relative proportions of faunal categories at Kartar Phase Type 1 sites are very similar to those at Hudnut Phase Type 2 sites. Several lines of evidence point to the use of Kartar housepit sites as simultaneous base/field camps: the intensive reuse of cobble implements attested by their edge damage (Lohse 1984); their detritus assemblages; and the faunal data.

The relative abundance of ungulate taxa may reflect general environmental conditions. The frequency of elk is similar in the Kartar and Hudnut Phases although slightly higher in the latter, and much lower in the Coyote Creek Phase. The relative abundance of sheep declines through time. As both sheep and elk historically have been seen to be very sensitive to pressure on their environment by humans, their overall decline might reflect a rise in regional human populations. Antelope, on the other hand, has its lowest relative abundance in the Hudnut Phase and highest in the Coyote Creek Phase. Even though numbers are small, the reciprocal relationship of antelope and elk in the phase assemblages is a tantalizing and irresistible opportunity for paleoenvironmental speculation, as both species are environmentally sensitive. Elk prefer a mesic environment conducive to grassland productivity, while antelope typically prefer an environment that is more xeric and productive of forbs. Elk prefer a winter range affording easy access to grassland, but antelope will browse on a number of species, emphasizing sage. Under most conditions the species are not considered competitors, and the project area conceivably could provide winter range for both species simultaneously where they could be taken, in proportion to their abundance, at the same time. The reciprocal relationship, while far from conclusive in itself, is another piece of evidence indicating the presence of a more mesic local environment during the Hudnut Phase.

Faunal Fragmentation

We also examined the fragmentation of faunal remains by site type. We expect some degree of consistency among the different kinds of sites in the distribution of average faunal fragment sizes; where fauna are used most intensively, we would expect greatest degrees of fragmentation; where they are least intensively used, the least reduction. Accordingly, we would expect Type 1 sites to have the smallest fragments, and Type 3 sites the largest. Because we do not have data on the size or weight of individual pieces of bone, we use the total bone count divided by the total weight as a rough index of average size. When project data are compiled (Table 6-18), however, the results are somewhat surprising.

Table 6-18. Bone and shell count/weight ratios.

Phase	Feature Site Type	Bone Count/ Weight	Shell Count/ Weight
Coyote Creek	1	3.58	0.64
	2	4.04	0.85
	3	4.57	0.31
	ALL	3.77	0.70
Hudnut	1	3.76	0.72
	2	4.48	0.60
	3	2.85	0.39
	ALL	3.81	0.65
Kartar	1	2.21	0.20
	2	4.11	3.00
	3	5.89	0.46
	ALL	2.43	0.20
ALL (mean)	1	3.33	0.30
	2	4.20	0.68
	3	4.03	0.39
	ALL	3.51	0.33

1. Kartar zones excluded; sample size not comparable.

Only one of the nine cases fits the model. Hudnut Phase Type 3 sites have the largest bone fragments in that phase (note that Table 6-18 shows the count/weight; therefore the larger the number the smaller the individual pieces of bone). However, Type 2 rather than Type 1 sites have the smallest. In the Coyote Creek and Kartar Phase sites the pattern is the reverse of the expected as the largest bone sizes are found in Type 1 sites and the smallest in Type 3. In all phases the fauna at Type 2 and 3 sites are dominated by small herbivores, reptiles, and fish, possibly accounting for the small bone fragments at them. The difference in patterns between Coyote Creek and Kartar on the one hand, and Hudnut, on the other, implies different functions of the site types in each phase.

Mussel Shell Size

We have no particular expectations for significant variation in mussel shell size between site types (which is why it is omitted from Table 6-1) but we examined this data for possible evidence of resource depletion over time. Chatters (personal communication) believes there is a gradual diminution in the average size of valves through time at sites in the RM 590 area, attributable to the effects of human predation. Because we do not have data on individual valve sizes, we used the count of valves divided by the total shell weight as a rough index of average shell size. Although further interpretation would require requantification of shell samples, we felt it worthwhile to conduct a preliminary examination to see where inquiry might better be focused in future work.

Shell sizes show no meaningful pattern among the site types, but display a tendency to diminish through time. Individual valves average 2.2 g in the Kartar Phase, dropping to 1.5 g in the Hudnut Phase and 1.3 g in the Coyote Creek Phase. It is of some interest that the relationship is parallel to the general trend of individual size for bone, perhaps indicating the action of weathering, whereby smaller fragments with proportionally greater surface areas are less likely to survive the chemical and mechanical ravages of time. However, a semilog relationship to time would be expected, which is not the case. The role of protection by sedimentation bears further investigation.

CONCLUSIONS

The foregoing discussions probably raise many more questions than they answer, but also show that it is practical to use the feature site types defined in this chapter to investigate those aspects of prehistoric economic adaptation found within the project area. This is not to say they are the only cultural units that could be used to do so, or even the best ones, but only to say that they have a good chance of showing general trends. The temporal units likewise are the most pragmatic ones for initial generalization although they do not allow us to pinpoint when change occurred in adaptive systems.

There certainly should be some attempt to segregate fishing and root processing camps among the Feature Type 2 and 3 sites in the Hudnut and Coyote Creek Phases, possibly by adding seasonality data. Likewise, the Feature Type 1 sites in the Hudnut Phase merit further examination to identify their function, particularly as there is some evidence that those on the south side of the river do not appear to be much like those on the north (Table 6-13).

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7. IMPLICATIONS OF ENVIRONMENT AND SITE DISTRIBUTION: A PRELIMINARY INVESTIGATION OF HUNTER-GATHERER ADAPTATIONS IN THE CHIEF JOSEPH DAM PROJECT AREA

by Leon L. Leeds

This chapter comprises a preliminary discussion of prehistoric land use and subsistence practice in the project area, based upon distribution of tested sites (see Appendix D for a listing of the data base). With respect to hunter-gatherer systems, the term subsistence is used here to refer to 1) the kinds of natural products used by human communities, including those used directly for food and those obtained for fabrication and maintenance of tools and structures; 2) the total and relative amounts of various products used; 3) the environmental zones and/or habitats exploited and the seasons of exploitation; and 4) the chain of product transformation, including methods of acquisition, preparation or fabrication, storage and maintenance, distribution throughout the community, and final use and discard.

In this discussion of land use, or settlement pattern, horizontally and vertically discrete clusters of materials (occupations) are considered events of discard that show where subsistence activities took place. The term **land use**, then, refers to 1) the kinds of activity loci and their internal organization, as measured by abundance and spatial patterning of artifact classes; 2) the spatial dispersion of types of activity loci in relation to environmental zones and/or habitats, 3) the duration and intensity of occupancy at each locus, and 4) to the inferred ways in which communities divided and reformed to move people and materials among the activity loci from season to season.

Most of these aspects of land use cannot be addressed conclusively on the basis of our testing data alone. There are serious geographic and systematic limitations to the data. First, while activity loci integral to any hunter-gatherer subsistence network probably are located in all environmental zones of the project area, only sites in the portion of the floodplain zone directly threatened by inundation were tested. Second, sampling fractions at each site were too low and strategies were not designed to provide the kinds of information needed; specifically, they did not provide a spatially representative sample of material, reveal spatial patterning of materials recovered, or obtain sufficiently fine chronological control. Nevertheless, several kinds of information from the testing project can be used to support an initial study of the local prehistoric subsistence and land use systems that might show what kinds of differences exist.

First, well over 200 sites are recorded in the reconnaissance and testing zone between Chief Joseph Dam and and the project boundary at Columbia River Mile (RM) 590. To these may be added a number of sites recently recorded in the area from RM 590 upstream to Grand Coulee Dam (Leeds et al. 1980). These sites have been identified over the last 30 years during survey, testing, and salvage excavations and constitute a massive sample of sites in the floodplain zone. While unbiased population parameters cannot be calculated because of lack of random sampling, the size and coverage of the set suggest a fair approximation of the target population.

Second, the sites have been assigned to two rudimentary classes which reflect major different kinds of activity: habitation sites (housepit "villages", rockshelters, and open "camps") and nonhabitation sites (inhumations, pictographs, talus storage cysts, cairns, hunting blinds, and rock "alignments"). The category assignments are based primarily on features visible at the land surface and associated artifact assemblages. While the data from the 79 tested habitation sites are insufficient for more detailed subdivision of habitation activities, they serve to validate or modify assignments based on reconnaissance data.

Third, the testing data are sufficient to roughly estimate major changes in site distribution over the last 5,000 years, the period of most intense occupancy in the project area. That is, while occupations in the testing data set cannot be assigned accurately to a finely divided chronological sequence, there is enough control to investigate possible differences in locational trends among older and younger components in the floodplain zone (Zone I).

Finally, environmental data for the project area are relatively well developed. While the present occurrence and distribution of fauna certainly cannot be projected into the recent or remote past, the general environmental zonation and the quality and distribution of habitats probably have been less altered in the project area than in many other archaeological study regions and have been studied and reported in some detail (Erickson et al. 1977). If we posit a general model of hunter-gatherer adaptation that relates subsistence strategy to land use patterns, the structure of critical resources in the project area should imply a specific pattern of site types in the floodplain zone. If the hypothesized relationship between resource structure and site location is shown to exist, it would suggest that the adaptation model at least would be appropriate to this area.

In the following sections, we derive expectations for site distribution and site type differentiation by applying an hypothetical hunter-gatherer subsistence strategy to the environmental structure of the project area. Characteristics of site distribution are then examined and tested by the quadrat and nearest-neighbor methods. In the following section, characteristics of the environment are summarized, methods of measurement are explained, and the degree of influence exerted by environmental structure on the site distribution pattern is assessed by multiple regression analysis. Questions of prehistoric change in subsistence and land use and comparability with other archaeological studies are addressed in the concluding section.

HYPOTHESES AND EXPECTATIONS

Environmental, ethnographic, and archaeological data from the project area and the surrounding region seem to closely match Binford's (1980) model of the "logistical" hunter-gatherer subsistence strategy. The climatic regimes of the Columbia Plateau have been typically warm-to-cool temperate, despite shifts in temperature and moisture, and natural resources show marked seasonal and geographic discontinuity. The ethnographically recorded subsistence/settlement pattern of the Sanpoil-Nespelem (Ray 1932) and Sinkaletk (Spier 1938) falls within the bounds of a logistical strategy, and there are archaeological indications that this general strategy is at least 5,000 years old on the Plateau (Leeds et al. 1980, Leeds 1981). In light of this information, it seems likely that spatial distribution and patterning of winter villages and open camps along the floodplain in the project area may be related to measureable characteristics of the surrounding environment. By analogy to the ethnographic pattern, we assume that sites with housepits represent the remains of activities related to winter habitation and to intermittent occupation in other seasons. The winter village is assumed to be the primary locus of long-term food storage. Semipermanent dwellings and storage facilities necessitate a variety of specialized construction and maintenance resources. The necessity for storage also would orient the subsistence system toward foods that can be processed and dried, while retaining sufficient nutrients to meet daily requirements during winter. These foods must be amenable to bulk collection considerably above immediate needs without severely reducing the next year's yield. Energy needed to find, harvest, process, temporarily store, and particularly transport storable foods back to the winter village during the harvesting season would demand a network of activity loci and logistical plans that minimized trip distances. We would expect that winter villages would tend to be positioned to minimize trip distance to the different critical resources which were the least uniformly distributed within the scope of the subsistence network.

Binford suggests that a central base (here a "winter village") will be located near the resource or resource group with the greatest bulk demand (1980:15). But minimization of distance to one resource may maximize distance to an equally important resource. Likewise, close proximity to an important resource might require a compromise in siting that may mean spending the winter in shadow, constructing houses on a 45 degree slope, or scrambling down a sheer, 60 m bluff to obtain water. While minimization of effort is the usual assumption in archaeological studies of hunter-gatherer economics (especially Jochim 1976), it should be recognized that determinants of location can operate at more than one scale. In arid regions, for instance, if a highly important food source is located at some distance from the river, the river is likely to exert the stronger influence in siting the central base. However, distance to the food source may be the same for a reach of several continuous miles along the river, whereby other kinds of resources, such as suitable building sites, firewood, or winter game ranges may be unevenly distributed. The next most important resource then will enter into decisions about where to site in yet smaller reaches, and so on for all important siting factors. How the contrary "pulls" arising from non-uniform distribution of important resources are resolved is usually termed **siting** in planning studies and this term will be used here. If siting decisions must be made in an environment of complexly distributed resources, the factors influencing the decisions should be inferrable from the spatial pattern and distribution of site types and the number, type and order of environmental variables which best explain the variance of site distribution. Two working hypotheses are entertained.

Hypothesis 1: Winter village siting is influenced by a variety of important resources that are unevenly distributed in time and space. This kind of distribution forces a system of ranking for the resources. Thus siting is best explained by a hierarchical ranking of siting factors.

Expectation A: Winter village sites will cluster at several scales. Their distribution will be random or uniform only at the scale that excludes the need to rank resource importance for siting decisions. This scale is designated the lowest scale.

Expectation B: Variance of winter village site distributions can be explained only by examining the siting effects of environmental variables that would be of ranked importance.

Hypothesis 2: "Open camp" and nonhabitation site" siting is influenced by resources in a different manner than winter village siting. Variability in their distribution will not be explained by the same environmental variables or ranking system that explains the variance of winter village distribution. (Expectations are implied by the hypothesis).

SITE DISTRIBUTION AND CLUSTERING

The zone of site distribution considered here lies along the floodplain of the Columbia River between Chief Joseph Dam and Grand Coulee Dam and includes both the Corps of Engineers zone of responsibility and the Bureau of Reclamation zone of responsibility from RM 590 to Grand Coulee Dam. The approximate locations of recorded nonhabitation sites are shown in Figure 7-1. Figure 7-2 shows the approximate locations of recorded habitation sites. Table 7-1 shows that of the 304 sites in Zone I, 21% are classed as winter villages, 49% as open camps, and 30% as nonhabitation sites. Seventy-one percent of the sites are located on the Okanogan County side of the river, while only 29% lie on the Douglas County side. Of those on the Douglas County side, only 5 (1.6%) are winter villages. Sixty winter villages are on the Okanogan County side.

Simple inspection of the distribution maps and a frequency histogram of site types per river mile both suggest nonrandom and nonuniform distribution along the 48 miles of the river (Figure 7-3). In general, the vast majority

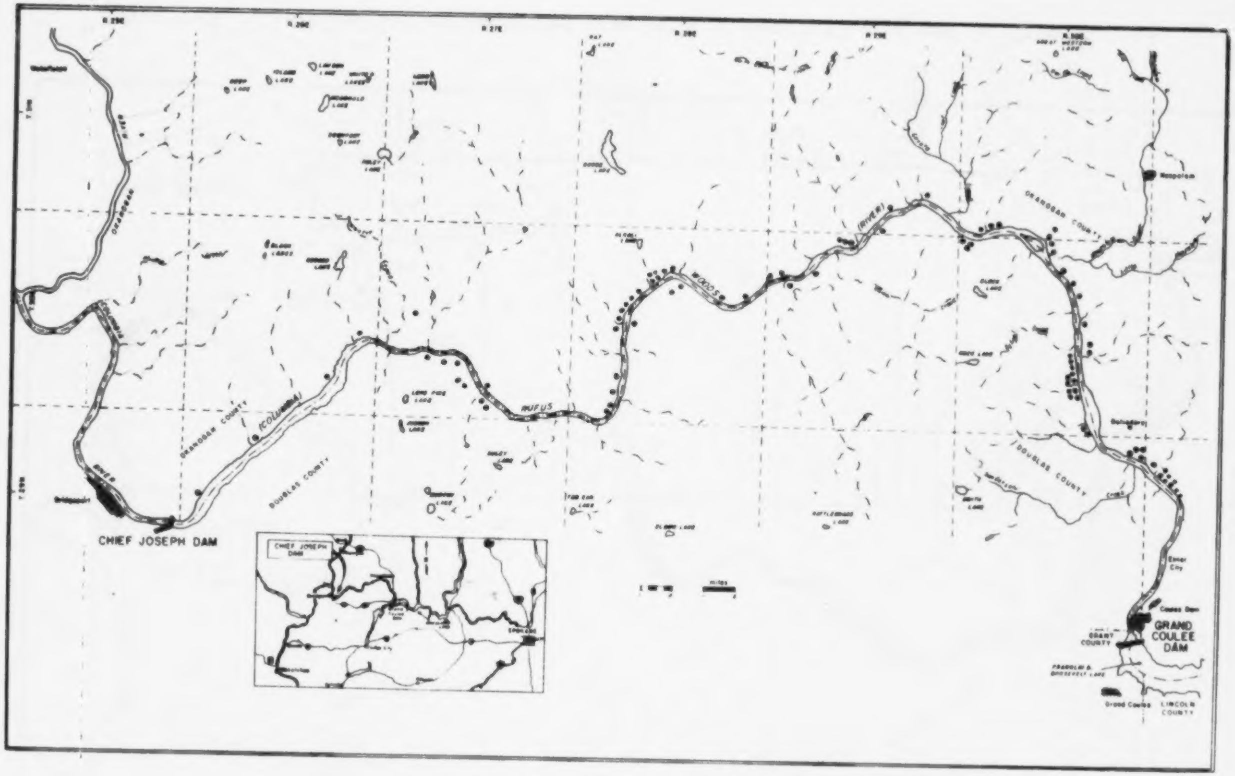
CHIEF JOSEPH DAM
COLUMBIA
RUFUS
WOODS
RIVER
OKANOGAN COUNTY
DOUGLAS COUNTY
OKANOGAN
GRAND COULEE DAM
GRANT COUNTY
LINCOLN COUNTY
Elmer City
Grand Coulee
CHIEF JOSEPH DAM

Figure 7-1. Distribution of recorded prehistoric nonhabitation sites in Zone 1.

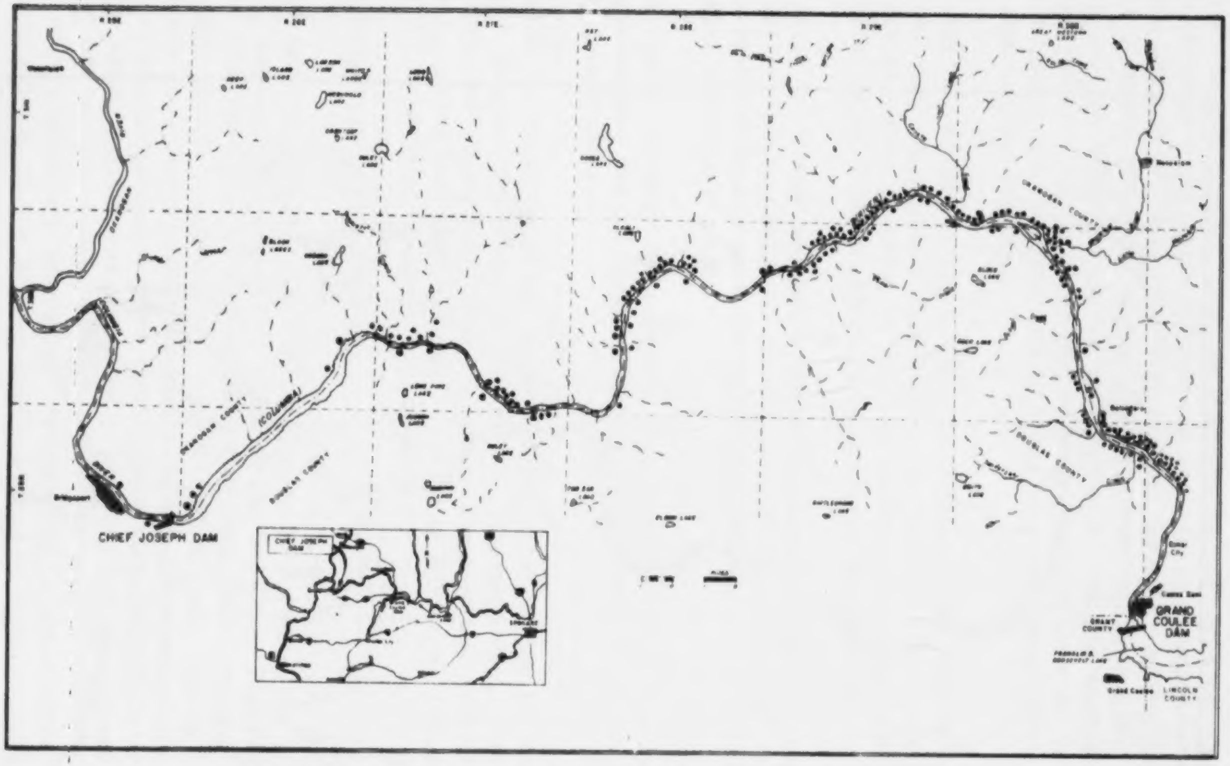
CHIEF JOSEPH DAM
(COLUMBIA)
OKANOGAN COUNTY
DOUGLAS COUNTY
Nespelem
Elmer City
Coulee Dam
GRAND COULEE DAM
GRANT COUNTY
FRANKLIN D. ROOSEVELT LAKE
Grand Coulee
LINCOLN COUNTY
CHIEF JOSEPH DAM

Figure 7-2. Distribution of recorded prehistoric habitation sites in Zone I.

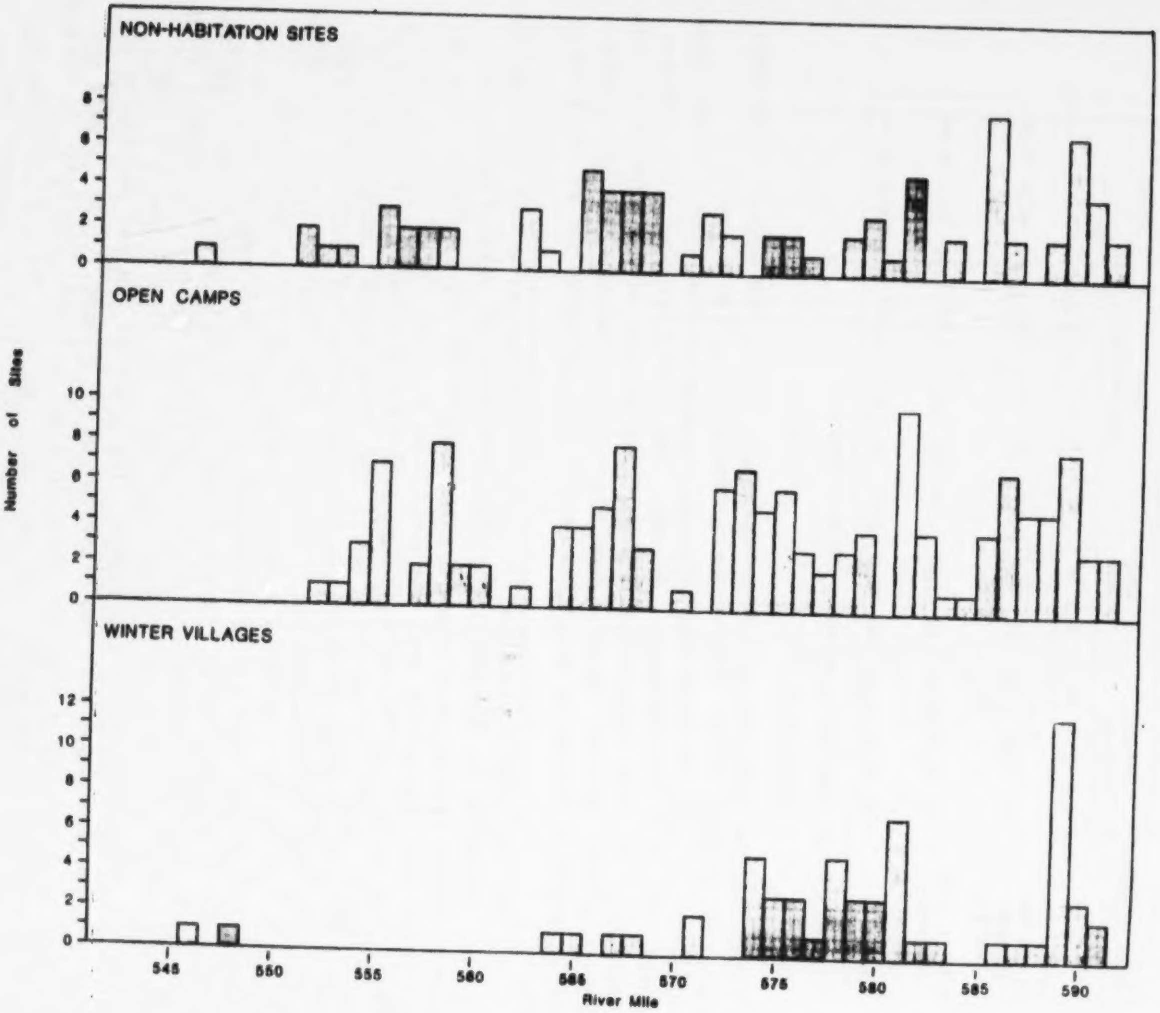

Figure 7-3. Bar graph of site frequencies by river mile.

Table 7-1. Number, percent and area (ha)[1] of sites by site type and river bank.

Side of River	Type of Site									Total		
	Winter Village			Open Camp			Non-Habitation					
	N	%	Ha	N	%	Ha	N	%	Ha	N	%	Ha
Left Bank (Douglas County)	5	1.6	1.13	53	17.4	4.81	30	9.9	1.28	88	28.9	7.22
Right Bank (Okanogan County)	60	19.7	30.30	96	31.6	11.73	60	19.7	4.02	216	71.1	46.05
Total	65	21.4	31.43	149	49.0	16.54	90	29.6	5.30	304	100.0	53.27

1. Area is not recorded for 40 sites (13.2% of sample).

of sites, and particularly of winter villages, are in the eastern (upstream) half of the project area. Additionally, the distribution suggests concentration along three or four distinct reaches of the river. Within these reaches, the distribution appears uneven. The distribution of site numbers along the river, then appears to be a positive outcome of Expectation A. The question arises, however, whether this distribution represents nothing more than a random accumulation which can be entirely accounted for by sampling error.

To test for significance and to characterize the pattern of distribution (random, clustered, or uniform) at different scales, an adaptation of the quadrat method was employed (Rogers 1974; Haggett et al. 1977:432). Due to its narrowness, the sample area was considered a linear rather than a two-dimensional array, and the 48 mile long reach was divided into 2 segments of equal length, then 3, 4, and so on up to 128. Site numbers were summed in each unit for each order of divisions, and the pattern of distribution was assessed by the variance-mean ratio statistic (v/m) (Whallon 1973), for which a quotient of 1.0 is considered random, greater than 1.0 is considered clustered, and less than 1.0 is considered uniform. The measure of association *d* (Haggett et al. 1977:417) and the *t* test (Greig-Smith 1964) for the significance of observed v/m allow us to reject the null hypothesis at the 0.05 level for all divisions greater than two. The first order division failed the *t* test by only a few points. The graph of v/m per decreasing unit size (Figure 7-4) shows that the distribution is grouped for all orders of division down to 128 but that the trend in distributional character is toward random as unit size decreases. The test confirms that the distribution is significant, and not explained by sampling error. It also suggests the validity of the visual impression that siting is determined by a resource ranking system that operated at scales of about a mile or two in length.

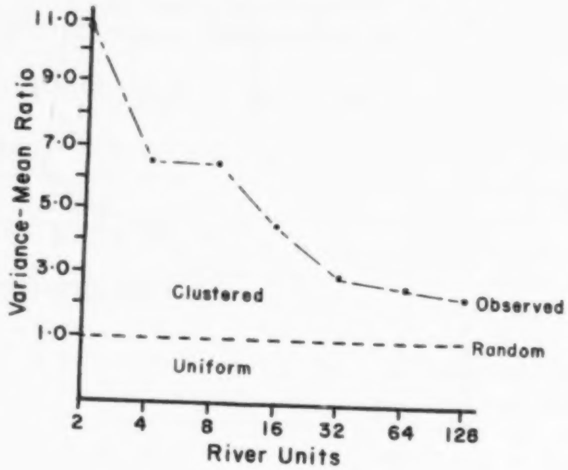

Figure 7-4. Variance/mean ratio for frequency of sites in units of decreasing size.

Distributional patterning at distances less than 2 miles was assessed by a linear nearest-neighbor analysis (Haggett et al. 1977:445). The method considers the ratio of reciprocal nearest-neighbor pairs to the number of pairs in the population from the first to the tenth nearest-neighbor order. The ratio varies between 0.0 and 1.0, where a random distribution is expressed by $2/3^n$, $\underline{n}$ being the $\underline{n}^{th}$ nearest-neighbor order. In this case, both the observed distribution of all sites and that of open camps are uniform to the tenth order, while that of winter villages fluctuates around the graph of the random function out to the seventh order (Figure 7-5). The nearest-neighbor statistic takes no account of hiatuses in distribution or of changing scales of measure, as long as the transitive relations among pairs do not increase at the expense of reciprocal relations.

Taken together, the variance/mean and linear nearest-neighbor tests constitute a positive outcome of Expectation A, suggesting that siting involves ranking of important resources, leading to loading on certain large reaches of the river, loading on smaller reaches within these, and so on. All criteria satisfied, site location within the smallest segments appears to be determined by two factors. The distributional pattern of winter villages

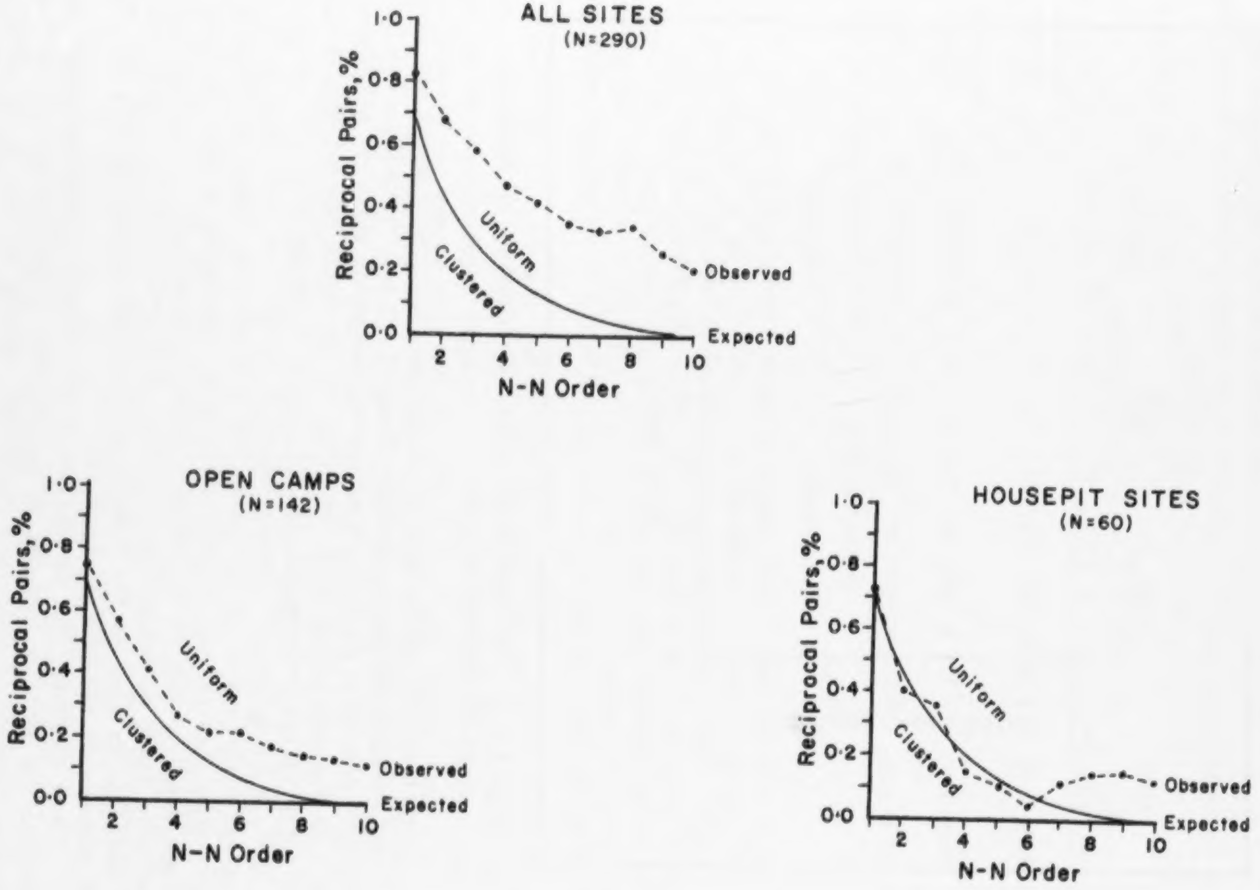

Figure 7-5. Linear nearest-neighbor relations of site types.

within less than a mile or so of each other is random using these variables and analytic techniques, suggesting that there are no patterned siting influences at this scale. The distribution of open camps at this scale, however, is uniform. The explanation among biological species for uniform distribution is competition. Presumably the dispersion pattern of open camps at the lowest scale is determined by zones of control: occupied habitation loci and surrounding catchment, or depleted catchment zones around recently abandoned loci of the same or a competing settlement network.

RELATION OF SITE DISTRIBUTION TO ENVIRONMENTAL STRUCTURE

The zone and/or habitat with which these natural resources are associated, their approximate relative abundance, and their season of harvesting is discussed elsewhere in this volume (Leeds, Chapter 1). It is important to note that most species in the resource base occur in the greatest numbers in nonsage habitats, associated with physiographic factors which have been more or less stable for at least the last 5,000 years: draws, cliffs, rocky slopes, streams and lakes, river islands and rapids, north-facing slopes, and landforms at higher altitudes. Although moisture and temperature vary seasonally, from year to year, and in cycles of greater length, the relative positions of these biogeographic units here are assumed to be analogues of the natural structure of the prehistoric environment. If the proposed model of hunter-gatherer subsistence strategy is correct and applicable to the entire sequence of occupancy represented by the sample of sites, then number of sites per unit distance along the floodplain should be linearly related to the area of biogeographic units and to the distance of important biogeographic units from the floodplain.

Plant and animal species are not the only resources of importance to hunter-gatherer peoples. In an arid region, potable water sources place a crucial constraint on the location of habitation. Because of the project limits, of course, all sites are near the river, but ease of access to the river from habitable surfaces varies along the floodplain. In some reaches, terraces lie only a few meters above the water, and banks are negligible, while at other localities, terraces lie many meters above the river. While paths down the sheer escarpments are easily constructed, carrying water (or wood) up such paths requires an appreciable expenditure of energy. The principle of "least effort" suggests that absence of high bluffs should be among factors in the siting of activity areas along the floodplain. Similarly, the degree of slope should influence decisions about where to site activities, particularly those concerned with long-term habitation. With respect to housepit villages, the construction of semisubterranean dwellings requires at least a meter of sediments above bedrock or cobble basement, and variation in the nature of sediments (sand, silt, gravel) along the river should influence site location. Exposed bedrock would preclude construction of the deeper styles of pit houses. For winter habitation, particularly in a deep canyon, solar radiation may be an important resource. How much winter sunlight strikes a given place along the floodplain varies according to the

Table 7-2. Coding form for the river mile attribute file.

Columns	Format	Description	Mnemonic
1-3	i3	River mile designation	RM
4-5	A2	County (OK or DO)	CNTY
6-8	F3.2	Total area (1.0×10^6 sq. ft.) within guide-taking lines	GTAREA
9-11	F3.2	Total area with a slope of more than 50% within guide-taking lines	STPAREA
12-14	F3.2	Total bedrock area with a slope less than 50% within guide-taking lines	ROKAREA
15-17	F3.2	Length of bluffs >5 m, divided by total length of shoreline in unit	BLUFF
18-19	F2.1	Solar exposure (0-4)	SOLAR
20-22	F3.2	Total area within 1/2 mile of river	AREA
23-25	F3.2	Total area of major draw bottoms within 1/2 mile of river	GULBOT
26-28	F3.2	Total area of rock or rockland within 1/2 mile of river	ROKROK
29-31	F3.2	Total area of pine community with 1/2 mile of river	PINE
32-34	F3.2	Total area of broadleaf community within 1/2 mile of river	BROAD
35	i1	Major valley (1=present, blank=absent)	VALLEY
36	i1	Plateau (Okanogan or Waterville) within 5 miles (1=present, blank=absent)	PLAT5
37	i1	Okanogan Highland within 5 miles (1=present, blank=absent)	HIGH5
38	i1	Omak Trench within 5 miles (1=present, blank=absent)	TRNCH5
39	i1	Pine community within 5 miles (1=present, blank=absent)	PINE5
40	i1	Pine forest, main, within 5 miles (1=present, blank=absent)	FORST5
41	i1	Lakes within 5 miles (1=present, blank=absent)	LAKES5
42	i1	Douglas fir within 5 miles (1=present, blank=absent)	DOUG5
43	i1	Plateau (Okanogan or Waterville) within 10 miles (1=present, blank=absent)	PLAT10
44	i1	Okanogan Highland within 10 miles (1=present, blank=absent)	HIGH10
45	i1	Omak Trench within 10 miles (1=present, blank=absent)	TRNCH10
46	i1	Pine community within 10 miles (1=present, blank=absent)	PINE10

Table 7-2, cont'd.

Columns	Format	Description	Mnemonic
47	i1	Pine forest, main, within 10 miles (1=present, blank=absent)	FORST10
48	i1	Lakes within 10 miles (1=present, blank=absent)	LAKES10
49	i1	Douglas fir within 10 miles (1=present, blank=absent)	DOUG10
50	i1	Plateau (Okanogan or Waterville) within 15 miles (1=present, blank=absent)	PLAT15
51	i1	Okanogan Highland within 15 miles (1=present, blank=absent)	HIGH15
52	i1	Omak Trench within 15 miles (1=present, blank=absent)	TRNCH15
53	i1	Pine community within 15 miles (1=present, blank=absent)	PINE15
54	i1	Pine forest, main, within 15 miles (1=present, blank=absent)	FORST15
55	i1	Lakes within 15 miles (1=present, blank=absent)	LAKES15
56	i1	Douglas fir within 15 miles (1=present, blank=absent)	DOUG15
57-60	i4	Length of rapids mapped on USGS and COE maps. 0≠missing data, 0=no rapids, hence no length.	RAPIDS
61	i1	River mile vicinity not analyzed because of amount of modification in recent years or unavailability of maps.	NODATA
COMPUTED VARIABLES			
		Usable area: GTAREA-(STPAREA + ROKAREA)	GUIDAREA
		Proportion of usable area: GUIDAREA/GTAREA	GUIDINDX
		Proportion of gully area: GULBOT/AREA	GULINDX
		Proportion of rockland or bedrock: ROKROK/AREA	ROKINDX
		Proportion of pine community: PINE/AREA	PININDX
		Proportion of broadleaf community: BROAD/AREA	BRDINDX
		Number of environments accessible within 5 miles: PLAT5 + HIGH5 +TRNCH5 +PINE5 + FORST5 + LAKES5 + DOUG5	ECOTN5
		Number of environments accessible within 10 miles: PLAT10 + HIGH10 +TRNCH10 +PINE10 + FORST10 + LAKES10 + DOUG10	ECOTN10
		Number of environments accessible within 15 miles: PLAT15 + HIGH15 +TRNCH15 +PINE15 + FORST15 + LAKES15 + DOUG15	ECOTN15

azimuth of the canyon and the steepness of the escarpment along the reach of river in question.

These constitute the minimum set of the most localized factors thought to influence where overwintering occurred along the project's floodplain. As noted earlier, environmental characteristics at a greater distance in Zones II, III, or IV, for instance, may outweigh these local characteristics at the locus of activity itself. For this reason, characteristics must be measured at a variety of distances away from the river. It should also be understood that the factors we have listed may not be the only factors influencing site location; and the distribution of our biogeographic surrogates may inappropriately group resource locations which, considered severally, might explain more accurately the observed variability of site distribution. Nevertheless, if the model is correct, and the biogeographic units relate to the structure of resources actually forming the subsistence base of the prehistoric inhabitants, then the variability of site-type distribution per linear unit along the river should depend to some degree upon measured characteristics of the present environment, expressed as independent variables of those same linear units.

MEASUREMENT OF SITING VARIABLES

The common units chosen for measuring siting variables are increments of the river course between Corps of Engineers river mile markers. Since the two sides of the river vary with respect to total numbers of sites, relative numbers of site types, and environmental characteristics, and since the river forms a kind of "semipermeable" barrier, the units are further divided into left (north, Douglas County) and right (south, Okanogan County) sides. Not all increments are a statute mile in length, and because the river bends sharply in a number of places, spatial units extending outward from the center line of the river are not of equal area. To maintain comparability, those environmental variables measured as areas are expressed as ratios of the total area within a unit. Two computer data files were constructed, one containing all sites recorded in the reservoir between Chief Joseph and Grand Coulee Dams (on which is coded grid and river mile locations, surface features, artifact class occurrences according to surface survey, testing, or salvage excavation, and other data), and the other containing environmental data per river mile unit (Table 7-2). For this analysis, the site file was reorganized to sum site type numbers and areas per river mile unit and was conjoined with the river mile file to form the data base.

Because of the expanding scale, three different data sources were used. For measurements within the guide-taking lines, corrected river mile markers were plotted on a large scale (1:960), Corps of Engineers geology map (E-51-20-11, 1967), and lines perpendicular to the center line of the river were drawn through the markers out to the guide-taking lines. The areas subtended on either side are considered the "total area" (GTAREA) of each RM unit (per side). (Note that this exercise does not measure variables on inundated terrain.) Again, since it seems safe to assume that the amount of exposed bedrock on one side of the river exerted no influence on site location on the other side, measurements at this and the next scale up were kept separate by side. With a polar compensating planimeter, total area, areas with a slope of greater than 50%, and areas of exposed bedrock were measured. Areas without rock and with a slope of less than 50%, along with all ratios, are derived by subsequent computation (Table 7-2, computed variables). Within each river mile, the effect of steep bluffs is assessed by the ratio of the length of escarpments greater than five meters high to the total length of shoreline. Since measuring winter solar radiation and shadow patterns directly would be extremely expensive, solar radiation is expressed by a ratio scale from 0 to 4, according to the azimuth of the river shorelines, as shown in Figure 7-6.

While our experience from testing and subsequent salvage operations suggests that housepits commonly are constructed in sandy sediments and seldom are dug through gravelly strata, sediments were found to vary greatly in a small area, and the attempt to measure the area of different sediment types from the geology map was abandoned.

The Corps geology maps do not extend much beyond the guide-taking lines and do not include data on vegetation. The areas of draw bottoms, exposed bedrock, talus slopes and/or dense fields of erratics, isolated communities of pine or mixed coniferous trees, and broad-leaf or macrophyllous vine and shrub communities were measured on 1978 Corps of Engineers air photo strips (ca. 1:1500). While measurement out to a kilometer or more from the river would have been preferable, the photos covered the area consistently only out to about 0.8 km. Again, the current river mile markers were transferred to air photos, the shoreline was copied 0.8 km planimetrically on either side of the river, and the river course was segmented by lines drawn through the river mile markers perpendicular to the center line of the river. Stereo pairs were used to improve feature interpretation. Areas were measured with a planimeter and expressed as the ratio of the feature's area to the total area of the unit (separately on each side of the river).

Since air photo-mosaic coverage of the entire study area is not readily available, environmental characteristics at distances greater than 0.8 km from the river were measured from USGS (1:62500) quad maps. At this scale and in this format, environmental data are restricted to distance, elevation and contour, location of lakes intermittent and perennial streams, distribution of the main forest of the Okanogan Highlands, and location of the larger outlying communities of coniferous trees. The strategy of measurement at this scale consists of assessing the "ecotonal" variability of the environment at eight, 16, and 24 km from the river. At each increment of distance, the presence or absence of the plateau environment, the highlands, isolated pine communities, the main forest, and lakes was recorded. The presence of mixed coniferous forest at higher elevations within the ponderosa pine forest was identified from the topography (north-facing slopes) and from personal knowledge of the local environment. Three major valleys (the Omak Trench, the Nespelem Valley, and the Grand Coulee) form potential communication links with other areas, and the proximity of the valleys to river mile segments was included. The ecotonal scores for each of the river mile segments was then summed for the

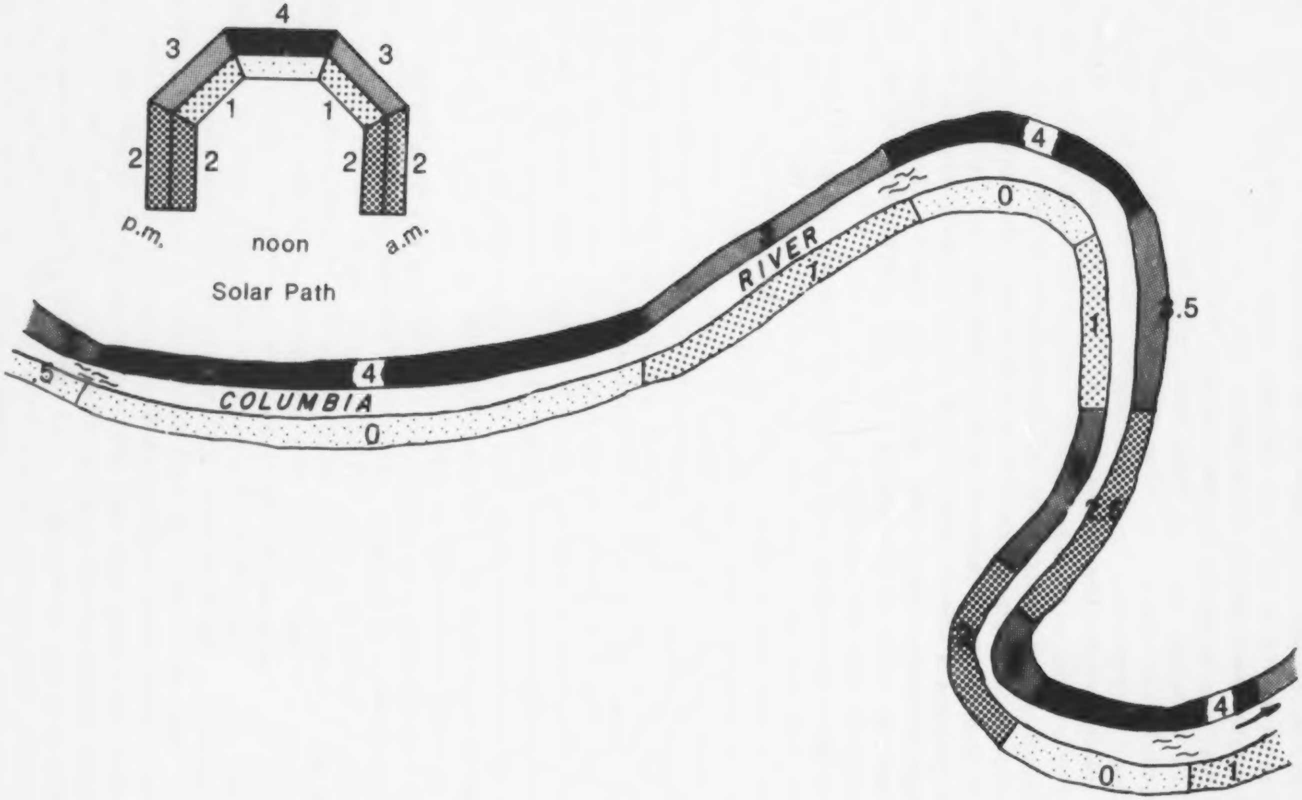
4
3
3
1
1
2
2
2
2
p.m.
noon
a.m.
Solar Path
COLUMBIA
RIVER
4
4
4
0
0
0
1
1
.5
.5

Figure 7-6. Winter sunlight and solar heating of habitation surfaces and nearby rock masses, expressed as a rough scale from 0-4.

three distances and taken as an index of environmental richness at increasing distance from the floodplain. It should be mentioned that the ecotonal indices are not measures specific to one or the other side of the river, as distant resource groups may influence site location on either side of the river. However, the intervention of the river would add to the total energy requirement to use a resource and should influence siting significantly.

TESTING THE SIGNIFICANCE OF SITING VARIABLES

Influences on site distribution were assessed by multiple regression analyses executed by the Statistical Package for the Social Sciences (SPSS) program (Nie et al. 1975). A forward, stepwise solution procedure was employed, in which the criterion for inclusion of an independent variable in the equation is $F \geq 1.0$. The F value is the ratio of the coefficient B to the standard error of B, a statistic allowing a test for the significance of the coefficient. In this procedure, all variables are independently assessed and then entered into equations in order of their partial correlation, the amount of variance in the dependent variable they individually explain. When all variables meeting the criterion of $F \geq 1.0$ are entered, F values are recomputed and an adjusted R^2 value, the proportion of variance in the dependent variable explained by the equation, is computed. The results are shown in Tables 7-3 and 7-4. In these tables, only independent variables with an F ratio of at

Table 7-3. Stepwise multiple regression suggesting influence of environmental variables on site location variability, north bank of Columbia River.

Independent Variable	Dependent Variables (# per river mile)											
	Winter Villages				Open Camps				Non-Habitation Site			
	O	F	P	B	O	F	P	B	O	F	P	B
Ecotone Index @ 5 miles	1	18.05	.00*	+					1	8.02	.00*	+
Solar Index	5	2.38	.13	+	2	1.35	.25	+				
Bluff Index	3	8.24	.00*	–					2	7.53	.00*	–
Draw Index	2	9.47	.00*	+	3	5.32	.03*	+	3	5.45	.03*	+
Rock Index	4	4.11	.05*	–					4	2.14	.15	–
Pine Index					1	4.06	.05*	+				
R^2 Adjusted (% of variance explained)		.52				.20				.29		

O = Stepwise order of inclusion
F = F ratio
P = Significance of F
B = Direction of relationship
* = H_0 rejected

Table 7-4. Stepwise multiple regression indicating influence of environmental variables on site location variability, south bank of Columbia River.

Independent Variable	Dependent Variables (# per river mile)							
	Open Camps				Non-Habitation Site			
	O	F	P	B	O	F	P	B
Ecotone Index @ 5 miles	2	5.23	.03*	+	6	6.78	.01*	+
Solar Index	6	2.53	.12	+	3	11.75	.00*	+
Bluff Index	1	5.73	.02*	-				
Draw Index	7	2.24	.14	-	5	6.58	.02*	-
Rock Index	4	3.48	.07	+	2	26.93	.00*	+
Rapids					1	21.82	.00*	+
Major Valley Intersection	5	2.28	.14	+				
Broadleaf Index	3	3.29	.08	+				
Pine Index					7	6.72	.01*	-
Surface Index					4	6.37	.02*	+
R^2 Adjusted (% of variance explained)	.24					.57		

O = Stepwise order of inclusion
F = F ratio
P = Significance of F
B = Direction of relationship
* = H_0 rejected

least 2.0 are shown, along with the order of their entry (0), the significance of F (which is given an asterisk where the probability of such a linearity arising in the population by chance is at the 0.05 level), and the sign of the intercept B which gives the direction of the relationship.

There is much to consider in these equations and considerable scope for refinement. The present results, however, suggest several tentative conclusions.

Five environmental variables representing different conditions within the floodplain, along the escarpments, and outside the Columbia River trench explain 52% of the variance of winter village location. Winter solar exposure and escarpments blocking access to the river are factors operating at the locus of habitation; draws and rock slopes refer to conditions within a half mile from the river; and ecotonal variability operates at yet greater distances. It should be mentioned that the ecotone index apparently heavily weights proximity to the ponderosa pine and Douglas fir forests, since other ecotones are almost equally accessible from most river miles; further, at 10 to 15 miles this index contributes nothing to the explanation, suggesting that **minimization** of distance to forest resources (or, more generally, to ecotonal richness) is the proper interpretation of the influence.

The observed frequency distribution of winter village sites along the floodplain, then, seems to be explained by conflicting tendencies: 1) to minimize distance to forest resources while remaining near the river; 2) at the same time, to maximize access to resources located in the draws dissecting the escarpment. The strong avoidance of rock might be expected due to construction requirements but may reflect the constriction of available surface, although this index is not correlated strongly with the optimum surface index. Avoidance of escarpments, which make access to water difficult, and adjustment of location to maximize winter sun, however, are expected outcomes of the analysis. These spatially conflicting influences on the placement of winter villages can be resolved to some degree by a ranked division of the available space. Over a long period of time, repeated occupation in the most preferred division will result in a pattern of distribution that we observe as the ranked clustering down to segments of about a mile, and in random or uniform patterns within the smallest divisions.

In contrast to winter villages, only 20% and 24% of the variance of open camp distribution is explained for locational frequencies on the Okanogan and Douglas County sides respectively. The included variables and their order differ enough from those explaining winter village location that we can argue with some certainty that the sites classed as "open camps" are different from those classed as "winter villages" (assuming the logistical model and the specification of **Hypothesis 2**). Open camps either include sites representing very different activity areas inappropriately grouped together, or the variables chosen to explain the locational variance of winter villages are inappropriate for explaining that of open camps, or both.

The greatest surprise in the analysis is the influence exerted by environmental variables on nonhabitation site locations on the Douglas County side of the river. With the omission of the solar index, the equation explaining nonhabitation site frequency along the Okanogan County side is identical to that explaining winter village location. The implication is obvious. Nonhabitation sites include cairns, identified burials, talus depressions (food caches or vandalized burials), rock alignments of unknown function, and pictographs. On the right bank, the majority of these appear to be closely associated with winter village habitation. The environmental influences on the location of such features along the left bank of the river are not easily interpreted. There are only five sites with identified housepits on the left bank, too few to be included in the analysis, and neither site distribution maps nor frequency histogrms show any spatial relationship between these and the nonhabitation sites. Without an hypothesis leading to the expectation of such an outcome we can only guess that these features do not represent a constellation of activities associated with any specific locus of the settlement network. That is, they are visible remnants of a wide variety of activities associated with specific but distinct habitats and physiographic features. It is perhaps important that nonhabitation sites on this side of the river represent the only kinds of sites whose frequency per river mile is influenced by the presence of rapids. The variable has the first order of inclusion in the equation (the highest partial regression coefficient) and is positively related to site frequency. While one might welcome the conclusion that a number of the nonhabitation sites are associated with subsistence activities at rapids, presumable with fishing, the association might just as well be due to other causes.

DISCUSSION

Analysis of the relation between site distribution and environmental factors, and by extension between subsistence strategy, critical resources, and land use, is neither complete or entirely conclusive, leaving considerable scope for further research. Fifty-two percent of the variance of winter village distribution has been explained by the interplay of five environmental variables, four of which are statistically significant at the 0.05 level, despite the small number of comparative units (n=45 river miles). This percentage is a respectable score, considering the fact that we are dealing with a complex system in which a wide range of impinging variables may affect any outcome and in which idiosyncratic behavior of individuals is expected. Nevertheless, the residuals cannot be ignored. Forty-eight percent of the variance has **not** been explained. There are technical responses to this situation, of course. At the present time, however, we have not examined residuals for the simple reason that there is no appropriate response to either possible result. A linear relationship of the residuals to site frequency per river mile unit would suggest variables not considered. Since we have apparently exhausted the environmental variability for which we have data, such an outcome would suggest the possibility of causes not related to the structure of resources which influence use-intensity along specific stretches of the floodplain. A random scatter of residuals would suggest inaccuracy of measurement. We expect both to be true and have no ready solution. We consider several sources of potential error.

One important question is whether the residuals vary according to time. Put another way, the question is simply whether the frequency pattern of sites per river mile has shifted at some time during the 5,000 years of most intense occupancy of the project area. If so, one might infer a change in environmental structure or subsistence strategy or both. We have not observed a major shift in environmental structure, at least for the last 5,000 years. Expansion of the pine forest during a moister climatic period, however, might increase the influence of the ecotone index; that is, it might explain clusters of winter villages lying downstream, at present at a considerable distance from the sage steppe-pine forest ecotone. An increase in earlier components in the downstream reach suggests a slight shift of this sort, if sampling error related to terrace height and inundation can be ruled out. In general, however, the number of testing components assigned to each period and interperiod interval is too small to reflect statistical trends. The data can be grouped, however, into two units representing Periods I-III (7000-2500

B.P.) and Periods IV-VII (2500-150 B.P.). The result is shown in Figure 7-7. While the numbers are still small, the cluster of components around RM 560 suggests that many of the sites recorded in this area reflect intensive land use primarily in the earlier periods. Even at this level of frequency, however, it is clear that the distribution pattern of the earlier components is much the same as that of the later ones. It seems reasonable to conclude that, while changing distribution of vegetation may have allowed modifications in the pattern of winter village location and subsistance tactics, there is no evidence here of a shift in underlying subsistence strategy.

A second potential for error lies in the fact that blanket reconnaissance did not take place before the project area was inundated. Systematic eradication of all sites that might have been in the downstream half of the project area certainly would create a spurious relation between site frequency and proximity to the pine forest. Other elements, more universally distributed, are involved in the ecotone index, however, and while proximity to forest vegetation seems important, it is not a decisive factor. While it cannot be demonstrated that there actually were fewer sites in the lower third of the project area, it seems very likely. Habitable surfaces in close proximity to the river probably were scarce in the lower third of the project area because of the lack of terrace development and the steepness of the valley. The negative influence of bluffs in other reaches is demonstrated in the regression analysis, and the low frequency of sites in such areas upstream beyond the influence of the first pool raise is quite clear, especially between the Nespelem River and Buckley Bar. We suspect inundation and landsliding are more likely to be responsible for the distribution of the residuals than for the linear relations. In any case, systematic loss of site matrix to erosion always is a hidden factor when surfaces active during the period of occupancy are sampled. If that is the only reason for the results we have obtained here, then similar studies in other areas surely will prove us wrong.

Yet another potential source of error is in the indirect method of measuring important environmental factors. First, the environmental variables are generalized, biophysiographic surrogates. While they appear to have served their purpose admirably, they undoubtedly are insensitive to highly localized critical resources. It would be better, of course, to measure the productive capacity and spatial distribution of the biological resources directly. However, faunal communities have been eradicated or greatly modified by Euroamerican settlement, and while floral species are substantially intact, the sampling, identification, and analysis of such materials are not within the scope of the present research. Secondly, the number of **sites** per river mile may not be a good reflection of the intensity with which a given stretch of the floodplain was used. The total area of site surfaces per river mile was considered as a dependent variable but was rejected because of instances of missing data and because the reconnaisance data are likely to be inaccurate in this regard. The number and/or area of **occupations** would be the most appropriate measure. Such a measure, however, cannot be completely realized, for obvious reasons.

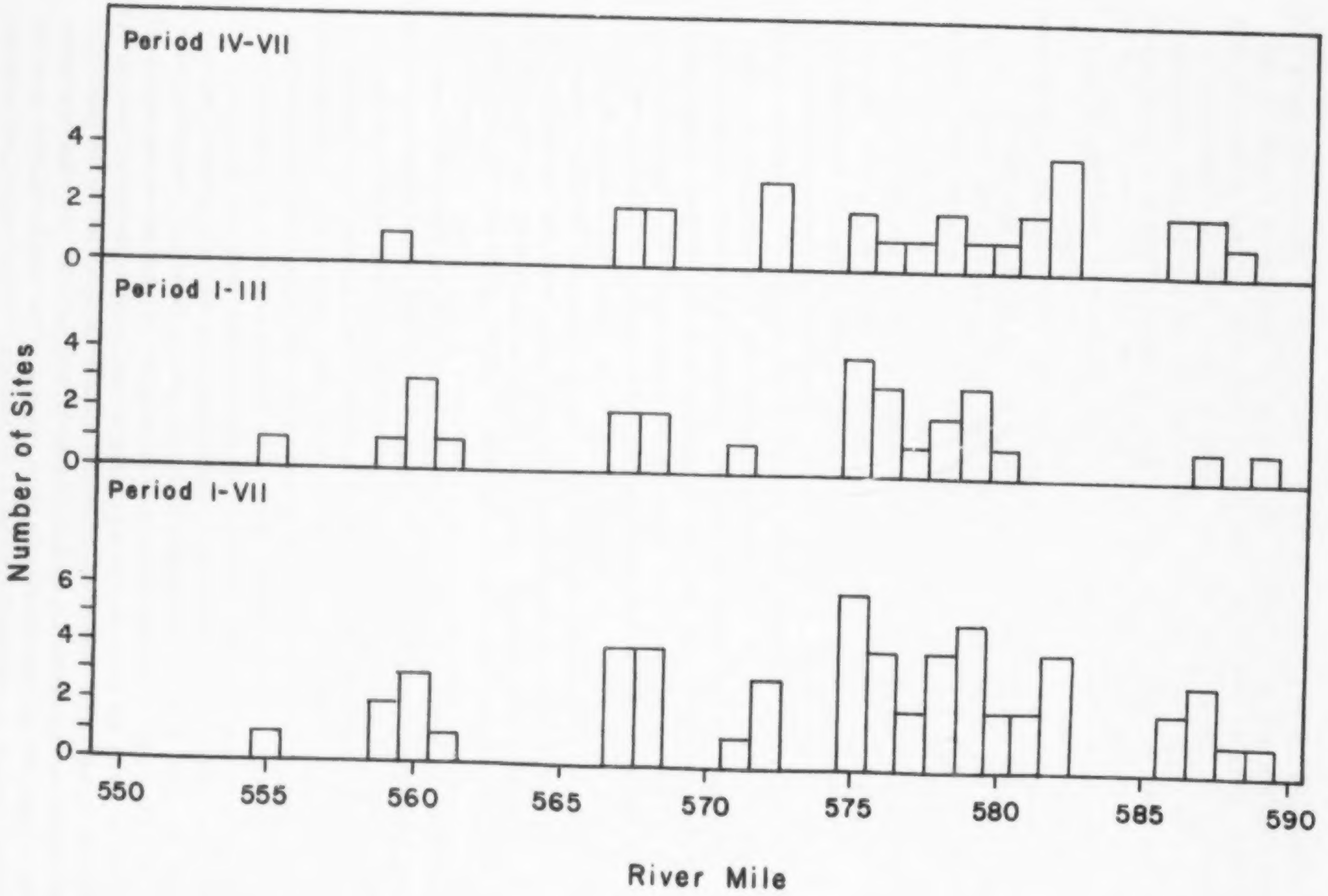

Figure 7-7. Distribution of components in Periods I-III and IV-VII compared to distribution of all tested sites.

There is also fair scope for inaccuracies vaguely classed as "measurement error" to account for some percentage of unexplained variance. A most important question, however, is whether there would be a close fit of the observed data to expectations derived from the model, even if all measurement error were reduced to a negligible percentage. Our guess is that the sources of error discussed might account for about 25% of the residuals. That is, only about three-quarters of the variance of the pattern of use-intensity along the floodplain could be explained by recourse to the proposed model of subsistence strategy.

To understand the implications of this conjecture, it is necessary to consider a distinction between the strategy and the tactics of subsistence economics. The model of subsistence strategy which we have assumed to explain the pattern of site distribution in the floodplain is relatively parsimonious and not only fits ethnographic observations of hunter-gatherer groups on a world wide basis (Binford 1980) but specifically fits the pattern of subsistence activities recorded in ethnographies of peoples living in and around the project area (esp. Ray 1932). The fit of the model to prehistoric activities in the project area is based simply on the recognition that resources critical to the subsistence base of hunter-gatherer groups are nonuniformly distributed both spatially and temporally. The strategy for overcoming this kind of incongruity in resources is straightforward and obvious, given that the necessary knowledge and technology were available: storage of food to bridge the fallow seasons, a wide resource base to compensate for year to year variability in productivity of resources, and procedures for simultaneous use of far-flung resources.

While the strategy outlined above is considered to exemplify the basis of the subsistence system in the project area, a variety of tactics are available to implement it. What we have not expressed in developing our expectations is the assumption that all parts of the population occupying the project area implemented that strategy in the same way. We have assumed explicitly that housepit sites marked habitations associated with food storage and maintenance, presmably for the winter months. Covertly, we have assumed that each part oriented their subsistence network independently to maximize access to the same **kinds** of critical resources. While, in the results of the nearest-neighbor analysis, we considered the possibility of competition for the same resources, competitive influences on settlement location could not be considered in the regression analysis. Similarly, we did not consider the possibility that redistribution of critical resources from segment to segment of the population (between closely allied kin units, communities, and so on) might influence the placement of the central base of habitation.

While Ray (1932) states that all winter villages of the Sanpoil-Nespelem were located on the floodplain, Post (in Spier, ed. 1938:11) mentions that some families among the Southern Okanogan wintered in the uplands and that stored foods from groups wintering on the floodplain were exchanged for upland products, (presumably meat and furs, and possibly vegetable resources). While we have, of course, no archaeological information about the existence of winter settlements in the upland zones, something of the same mechanism may be in operation on the floodplain. During periods of high population, some groups might be forced to locate along reaches of the river which are less than optimally situated for exploitation of all critical resources. Conversely, location in such reaches might be a tactic for exerting control over a wider territory and for more systematic exploitation of **some** resources; shortages created by extension of the network could be accounted for by intragroup exchange. In any case, it seems clear that to account fully for most of the variance in the spatial distribution of sites representing the central base of a logistics network, cultural as well as environmental factors must be taken into account. Cultural responses are by no means variables **determined** by environmental factors; rather, environmental factors are variables in part determined by cultural systems; once determined, they simply constitute the bounds within which the system operates comfortably.

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8. SITE CLUSTERING

by Lawr V. Salo

Leeds' earlier detailed study of site distribution focused on the relationship of site location to environmental features, using all sites, regardless of age to site location (Leeds, Chapter 7). Since that time, the number of well-dated components has been substantially increased as the survey and salvage programs at the project have drawn to a close. There is now an opportunity to look at site distribution with an eye to disclosing change through time.

We have conducted an examination of site distributions with each of the three project phases. Our graphic approach is a departure from the statistical approach used by Leeds. In part, we can do so because the earlier work established certain traits of site distributions in the project area. For instance, the locational analysis suggests that whenever possible, communities comprising several households chose wintering site (central base) locations with the most convenient access to the full suite of environmental resources needed to sustain the community. This tendency could be made apparent through graphic demonstrations or by multivariate statistical techniques. Primarily using the latter, Leeds found that sites appeared to cluster at a variety of scales that were progressively finer proportional divisions of the 45-mile river length. Only at divisions less than about 6 mile groups did the tendency toward clustering become less apparent.

At this point we intend to concentrate on community siting rather than individual household sites, as Leeds' study suggests that further investigation of the latter would be futile if only the project's data were used. We do not suggest that we can detect actual prehistoric communities. Instead, we identify site clusters as analytic surrogates for communities, that is groups of households. We then examine spatial and geographic relationships among clusters. In this way we hope to detect temporal changes in culturally patterned siting strategy, hoping that the larger scale will screen out idiosyncratic behaviors of households noted by Leeds. The environmental influences cannot be established conclusively by this study, but we compare site clustering to faunal distributions and other data to suggest reasonable explanations that may be tested by future investigations.

Other studies (Salo, Chapter 6; Miss, Chapter 9) suggest that there have been changes in adaptive systems in the project area through time. Older occupations may have been associated with adaptive systems closer to the foraging than the collecting end of the continuum. The differences among them may be important to study of cultural evolution, but may reflect tactical rather than strategic aspects of plans for living. We expect that changes in site distribution at the project are most likely to show shifts in subsistence tactics in response to the kinds of environmental and cultural changes that we know have occurred in the study area.

This study is confined to prehistoric habitation sites. Leed's study of nonhabitation site siting cannot be improved upon as none of the sites have since been dated save burial sites. There are too few burial sites in the project to support sophisticated locational studies. Further, we are most interested in prehistoric subsistence economy and beyond the direct evidence of individual health, populations and special technology that burials themselves provide, their locations within the floodplain zone are not likely to be illuminating. They can, however, suggest community loci.

EXPECTATIONS

To facilitate investigation of the relative location of each phase along the foraging/collecting continuum, we constructed a model for the expected distributional characteristics of site types within foraging and collecting systems (Table 8-1). We have defined four variables to use in examining these characteristics in site distributions (Table 8-2): 1) the geographic concentration of site clusters; 2) characteristic cluster dispersion; 3) site density within clusters both total and for each kind of site; and 4) site type diversity of clusters. Site clusters, for the purpose of this discussion, are defined simply as modes in the distribution of any kind of site or combination of sites within the census zone. They may be observed at any geographic or temporal scale.

The first variable, "geographic concentration of site clusters" is intended to measure the locus and extent of a community. The modes in site type frequency by census unit identify the loci. We make several assumptions in using this technique for disclosing community locations.

1) "Community" is an archaeologically identifiable unit of social organization. For the purpose of this study, "community" is defined as a group of households in a geographically delimited area. We assume that the households of a given community tend to interact with each other to a greater extent than they do with households of other communities. Within the community we assume that households vie for whatever sites are believed to be most desirable, and that the most desirable locations would show up archaeologically as the most frequently used areas.

2) Low frequency of land use is shown by relatively low frequency of archaeological sites in a census tract.

3) We assume that we are investigating some kind of central based collecting subsistence system (Leeds, Chapter 7).

Table 8-1. Expected site representation and distribution in foraging and collecting systems.

Kind of Site	Adaptive System	Clustering Variables			
		Geographic Concentrations (Clusters)	Cluster Dispersion	Site Density Within Clusters	Site Diversity Within Clusters
Central Bases (Type 1) (Winter village)	Collecting	Many	Narrow	High	Low
	Foraging	Fewer	Wide	Low	High
Field Camps (Type 2) (Spring village, Hunting camps, Fishing camps, Root camps)	Collecting	Many	Wide	Moderate	High
	Foraging	Fewer or none	Wide if present	Low	Low
Locations/Stations (Type 3) (Salt licks, Quarry camps, Butchering camps, Tule camps, Kill sites)	Collecting	Relatively Few	Narrow	Moderate	High
	Foraging	Many	Wide	Moderate or high	Low or moderate

1. Contrasts are between same type of site in different systems, not between types of sites.

Table 8-2. Site location and clustering variables.

Parameter	Statistic	Measured Variable
1. Site type by unit (phase and reach)	Mode	Geographic concentration of site clusters
2. Distance between modes in site type by unit	Mean	Characteristic cluster dispersion
3. Sum of site type per unit	Mean	Cluster site density
4. Site type percentages by mode	Mean	Cluster diversity

4) For a central based collecting subsistence system, the key element in disclosing community locus is the central base site. For this study we assume that the central base site is a Type 1. Other kinds of sites occur in the community and must not be ignored in defining community locus, but the central base sites are the primary evidence. As we have drawn our data from both testing and salvage level information we also assume that sampling error has not grossly distorted the identification of site types based on feature inventories.

5) The loci of modes in the frequency of different kinds of sites in the total census area are sufficient to indicate the geographic concentration of a site cluster. 6) Greatest weight is given the mode in Type 1 site distribution when determining a cluster's geographic concentration. 7) The size of the cluster is the total area covered by each mode, weighing the combined effects of modes in all site types.

The second variable, "characteristic cluster dispersion," is intended to measure the geographic distance among communities. The mean geographic distance of modes of site type defines this variable. In addition to basic assumptions of the first variable, key assumptions here are:

1) A census area must be chosen with multimodal characteristics in multiple site types.

2) "Mode distance" is determined by measurement from peak to peak expressed in integral census increments as the closest interval downstream from the peak.

3) The key mode among all site types generally is that for site type 1, but characteristic cluster dispersion should be determined on average values for intermode distance of all site typos.

4) The census area is not widely disparate ecologically, but may have internal differences that reflect geographically different combinations of microenvironments.

This variable also conveys information about the characteristic size of communities and their territory, and helps describe the adaptive success of a group of culturally related communities.

The third variable, "cluster site density" is designed to measure the intensity of use of local resources by a community. The mean of the sums of each site type in each spatiotemporal unit for each cluster yield the characteristic for each cluster. A phase's local characteristic cluster site density is the mean value of all cluster site density values. Key assumptions not covered by previous discussions are:

1) How intensely an area was used is actually reflected by the number of sites (or different occupations) in the area.

2) Sedimentation rates are adequate to preserve evidence of enough separate occupations that the first assumption is reasonable.

3) Erosional episodes have not destroyed occupation evidence selectively.

4) The statistic is adequate for the rough measure of density.

5) As the study area is a narrow floodplain, the use of linear measurement is an adequate surrogate for a two-dimensional approach.

The fourth variable, "cluster diversity", is designed to measure the complexity and degree of organization of a local community. The diversity of each cluster is shown by the ratio of site types in each mode. A phases's characteristic cluster diversity is the mean of all modes' diversity measurements. The key assumptions of this analysis are:

1) Progressively larger numbers of different kinds of sites reflect progressively more complex economic organization.

2) The site feature type classification used in this study is adequate to show rough trends of social evolution.

METHODS

Our study of site distribution uses sites/component frequencies summed by 5-mile reaches in recognition that this interval is approximately the order of scale at which the tendency toward normal distribution becomes more uniform (Leeds, Chapter 7:Figure 7-5). We use a 50 mile total reach, from Columbia River Mile (RM) 545 to RM 595. River miles are indicated on 15 minute USGS maps. (The reader should be aware that RM designations change through time as the position of the river mouth changes and as its course alters). Site data are summed within reaches designated by perpendiculars to the river flow axis drawn through the appropriate RM markers on the maps. All sites are confined to the floodplain, Biophysiographic Zone I of Leeds et al. (Chapter 1).

Site/component data for habitation sites can be found in Appendix D, Tables D-1 and D-2. We have assembled data at the finest chronological level available for each site. Sites known from photo inventory or reconnaissance have but one component: prehistoric. Sites which have been tested only have, as a rule, two components; more extensively excavated sites have 3 or more components.

Sites/components also are classified according to the kinds of features present at each, as surrogate measures for different kinds of sites that might be expected in collecting or foraging systems (Binford 1980). For untested habitation sites, the only distinction that can be made is the presence of housepits. Thus sites known from reconnaissance or aerial photographic inventory are split into the categories "housepit" and "open camp" (Table 8-3). Tested and salvaged sites were divided into three classes (Salo, Chapter 6): Type 1 sites with house floors or housepits and at least one other kind of structured feature; Type 2 sites with a discrete living floor and one feature or midden and one other feature, and Type 3 sites with one or no features. Respectively, these types are surrogates for central bases, field camps, and locations/caches/stations.

All components were displayed by 5 mile reach by riverbank (Table 8-4). The river itself appeared to Leeds to be a significant siting factor, possibly as a barrier to day-to-day communication and thus it was included in the current investigation. The distribution of Leeds' environmental zones within 15 km of the project was summarized in schematic, not-to-scale form (Figure 8-1). Some modifications of the biophysiographic zones were made to better indicate environmental diversity. We split the pothole lakes upland from Zone IIIL and IIIR. We also split upland grassy valleys (elk and antelope habitats) from Zone IIR. Forested parts of Zone IIIR (from USGS 15 minute maps) also were lumped with Zone IV. As Zone I is uniformly distributed in the study area, we did not include it in the map. We added perennial streams and rapids, however.

The frequency of all prehistoric sites, regardless of age, by 5 mile reach is shown in Figure 8-1. Sites were counted separately on each bank. The breakdown of total sites into open camp and housepit sites also is shown, disclosing occurrences of both types on both sides of the river. In this exercise, components that had been more finely typed were grouped into housepit/open camp categories.

Chronologically classified and feature-typed components then were displayed in similar fashion but not compared with the environmental feature distribution (Figure 8-2). The chronological divisions are the project's three phases, each roughly 2,000 years in length. Finer subdivisions, although feasible, would have been unlikely to result in clear patterns due to small sample size, especially in the earlier period.

RESULTS AND DISCUSSION

With the exception of winter villages added by aerial photogrammetry, the linear distribution along the river of housepit and open camp sites over the 6,000 year span of the prehistoric record at the project is virtually identical in the 1981 (Figure 7-4) and present study (Figure 8-1). If numbers of sites/occupations are any indication, overall use of the south bank of the river was less intense for each kind of site. The reaches above RM 565 received greatest use; major site clusters occur in the RM 565-570, 575-580, and 585-590 reaches, although intervening reaches also have occupation.

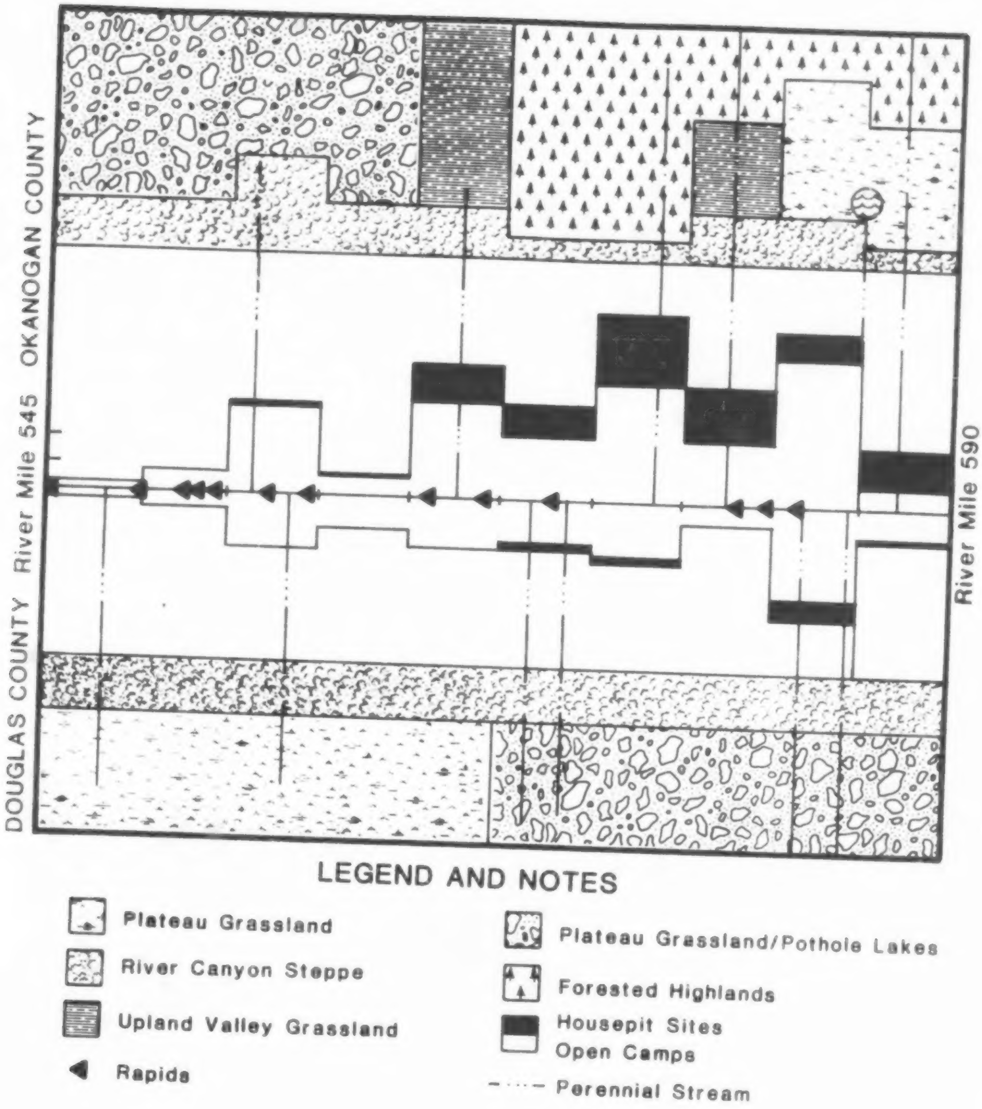
DOUGLAS COUNTY River Mile 545 OKANOGAN COUNTY
River Mile 590
LEGEND AND NOTES
Plateau Grassland
River Canyon Steppe
Upland Valley Grassland
Rapids
Plateau Grassland/Pothole Lakes
Forested Highlands
Housepit Sites
Open Camps
Perennial Stream

Figure 8-1. Housepit and open camp site distributions in comparison to environmental features.

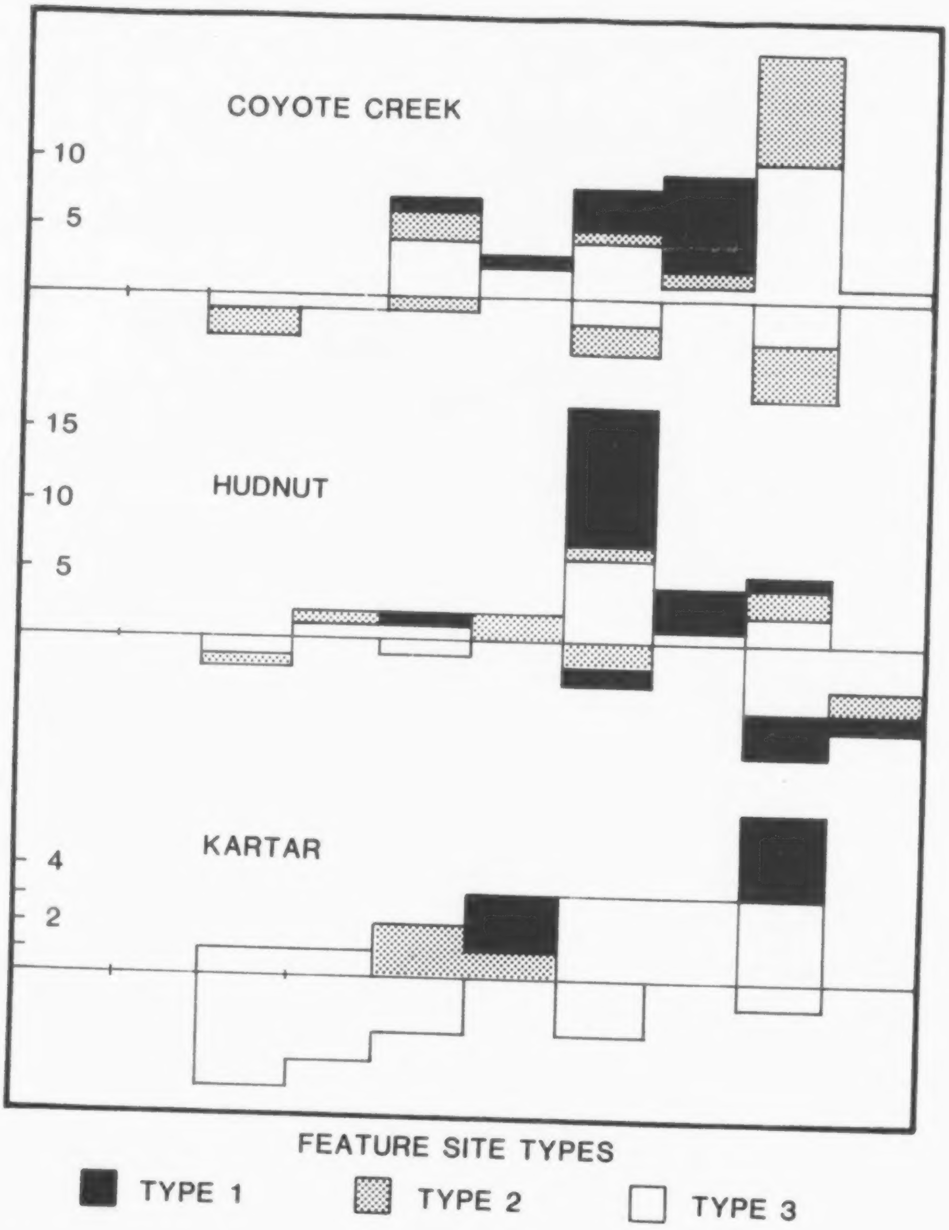

Figure 8-2. Site distributions by phase.

Table 8-3. Habitation site inventory (based on surface evidence only) by reach.

Reach	River Mile	Foot Survey[2]		Aerial Photos[3]		Total			% of Total Inventory
		Housepit	Open Camp	Housepit	Open Camp	Housepit	Open Camp	All	
1	545-550	–	2	–	2	–	4	4	1
2	550-555	–	2	–	8	–	10	10	2
3	555-560	–	18	1	9	1	27	28	11
4	560-565	–	5	1	3	1	8	9	4
5	565-570	3	21	5	6	8	27	35	13
6	570-575	2	10	5	2	7	12	19	11
7	575-580	15	19	1	–	16	19	35	19
8	580-585	11	16	1	–	12	18	30	10
9	585-590	–	28	3	2	9	30	39	22
10	590-595	11	12	–	–	11	12	23	7
All	545-595	48	135	17	32	65	167	232	100

1. Inventory from Munsell and Salo 1977 as modified by Jermann et al. 1978; Leeds et al. 1980 and Leeds et al. 1981; Chatters 1984 a and b, and Mass 1982.

2. From Appendix D, Table D-1.

3. From Appendix E, Table E-1.

Table 8-4. Habitation site inventory (based on surface evidence only) by reach and river bank.

Reach	River Mile	North Bank (Okanogan Co.)	South Bank (Douglas Co.)	Total	Ratio Within Reach	
					North	South
1	545-550	2	2	4	50	50
2	550-555	6	4	10	60	40
3	555-560	26	15	41	63	37
4	560-565	6	10	16	38	62
5	565-570	38	14	52	73	27
6	570-575	27	14	41	66	34
7	575-580	54	18	72	75	25
8	580-585	34	6	40	85	15
9	585-590	50	33	83	60	40
10	590-595	17	10	27	63	27
All	545-595	260	126	386	67	33

When finer time intervals are considered (Figure 8-2), some interesting changes in pattern of distributions are evident on visual inspection. The patterns perceived for each phase are discussed below, followed by a separate consideration of data biases and their effects on perceived patterns.

The following results are evident (see Table 8-5 for numeric data and Table 8-6 for a statistical summary). The Kartar Phase shows only two site clusters in the study area. Type 1 (housepit) sites are spaced at 15 mile intervals. Cluster size is about 20 miles. Site density in each cluster averages 0.88 site per river mile. Type 1 sites comprise 16% of the average cluster, Type 2 (field camp) sites 10%, and Type 3 (locations/stations) 74%.

Table 8-5. Dated and typed sites by phase and reach.

Reach	River Mile	Kartar Phase				Hudnut Phase				Coyote Creek Phase			
		Feature Site Type				Feature Site Type				Feature Site Type			
		1	2	3	All	1	2	3	All	1	2	3	All
1	545-550	–	–	–	–	–	–	–	–	–	–	–	–
2	550-555	–	–	–	–	–	–	–	–	–	–	–	–
3	555-560	–	–	5	5	–	1	1	2	–	2	1	3
4	560-565	–	–	4	4	–	1	1	2	–	–	1	1
5	565-570	–	2	2	4	1	–	2	3	1	3	4	8
6	570-575	2	1	–	3	–	2	–	2	1	2	–	3
7	575-580	–	–	5	5	11	3	6	20	3	3	6	12
8	580-585	–	–	3	3	3	1	–	4	7	1	1	9
9	585-590	3	–	4	7	4	2	7	13	–	12	13	25
10	590-595	–	–	–	–	1	2	3	6	1	–	–	1
All	545-595	5	3	23	31	20	12	20	52	13	23	26	62

The Hudnut Phase shows four site clusters. Housepit site cluster spacing is 10 miles. Cluster size is 10 miles. Site density in each cluster averages 1.3 per river mile. Housepit sites comprise 38% of the average cluster, field camps 23%, and locations/stations 38%. This phase also shows a use of the south side of the river for housepit sites.

The Coyote Creek Phase shows four site clusters. Housepit site cluster spacing is 12.5 miles, but this figure probably is closer to 10 due to sampling biases. Cluster size is 10 miles. Site density in each cluster averages 1.55 per river mile. Housepit sites comprise 33% of the average cluster, field camps 30%, and locations/stations 36%.

Before interpreting the results from the standpoint of cultural evolution, some discussion of data biases is warranted. In general, the best use that can be made of the data in Table 8-6 is rough illustrations of trends.

Table 8-6. Locational statistics by phase.

Variable	Karter Phase		Hudnut Phase				Coyote Creek Phase			
Variables by Phase										
Mode for Site Type										
1	570, 585		565, 575, 585				565, 580, 590			
2	565		575, 585				555, 565, 575, 585			
3	555, 575, 585		555, 565, 575, 585				555, 565, 575, 585			
Cluster Dispersion										
All	1/20 miles		1/10 miles				1/10 miles			
1	1/15 miles		1/10 miles				1/12.5 miles			
2	–		1/10 miles				1/10 miles			
3	1/15 miles		1/10 miles				1/10 miles			
Cluster Site Density										
All	0.88		1.30				1.55			
1	0.12		0.50				0.35			
2	0.15		0.30				0.58			
3 .	0.58		0.28				0.65			
Cluster Diversity										
1	16		38				33			
2	10		23				30			
3	74		38				38			
Variables by Cluster										
Location of site clusters (extent of mode)	555-575	575-595	555-565	565-575	575-585	585-595	555-565	565-575	575-585	585-595
Identifier	KA	KB	HA	HB	HC	HD	CA	CB	CC	CD
Cluster Site Density										
All	0.75	1.0	0.4	0.5	2.4	1.8	0.4	1.1	2.1	2.6
1	0.1	0.2	–	0.1	1.4	0.5	–	0.2	1.1	0.1
2	0.2	–	0.2	0.2	0.4	0.4	0.2	0.5	0.4	1.2
3	0.6	0.8	0.2	0.2	0.6	0.1	0.2	0.4	0.7	1.3
Cluster Diversity (% of Each Site Type)										
1	12	20	–	20	58	26	–	18	48	4
2	19	–	50	40	17	21	50	45	19	46
3	69	80	50	40	25	53	50	36	33	50

Mode bounderies are by 5-mile unit, determined by change in slope. Mode peaks designated by closest downstream river mile.

Testing at the project has been intense (Table 8-7). The percentage of habitation sites tested in each five mile reach ranges from 22 to 66 percent. Between RM 555 and RM 570, testing averaged about 30 percent in each five-mile reach, and between RM 570 and 590, testing averaged about 60%. Relatively few sites have been tested in RM 590-595 as this reach lies outside the Chief Joseph Dam project.

The lower half of the study area is the most deeply inundated, so our measure of intensity of use is less likely to reflect actual prehistoric use of that area in comparison to the upper half. However, the lowest 15 miles seem never to have been used much. The foregoing two biases do not seem to affect one of the most informative statistics, the spacing of site clusters.

Another universal sampling bias affects the utility of the numeric data. Beyond unity, the number of occupations at a site is directly proportional to the testing or salvage intensity (Table 8-8). Consequently the cluster site density and cluster diversity statistics are less reliable. Finally, data in the RM 585-595 reach are biased for the Coyote Creek Phase by destruction of housepit village sites before they could be sampled and by the component definitions at 45-OK-197 (Chatters 1984a) which are much finer than the analytic zone divisions made for the project sites. The cluster site density and diversity statistics for this reach are of no use for systematic comparisons with other reaches.

Cluster dating strongly suggests cluster contemporaneity (Tables 8-9 and 8-10). The greatest weaknesses in radiocarbon control also covary with overall availability of sites for sampling, so in retrospect there is little that could be done to correct for these weaknesses. Type 1 and 2 sites are the most thoroughly dated; Type 3 sites the least. As cluster definition depends most heavily on Type 1 and 2 locations, this deficiency is least worrisome.

INTERPRETATION

Considering all community location data, the major change is between the Kartar and the succeeding Hudnut and Coyote Creek Phases. The Kartar community territories are twice as large as, and site densities in them are half those of their successors. The Kartar Type 1 sites occur only in locations that we infer are the very best winter range for browsing and grazing ungulates (see Figures 8-1 and 8-2), in contrast with the later phases which seem to have other geographic foci. The occupations appear to focus in the Hopkins Canyon and Belvedere vicinities. The Kartar Phase clusters have the least even proportions of site types; the phase has a very high proportion of Type 3 sites, presumably locations/stations (Figure 8-4). It also is the only phase without Type 2 (field camp) sites on the south bank of the river.

With regard to inferences about adaptive systems, the above observed results, in contrast with model expectations (Table 8-1), show clear evidence of change from Kartar to the later phases. The locations of Type 1 sites and the scarcity of Type 2 sites suggest that Kartar base and field camps were more nearly equivalent than such sites were for later peoples. The ability to

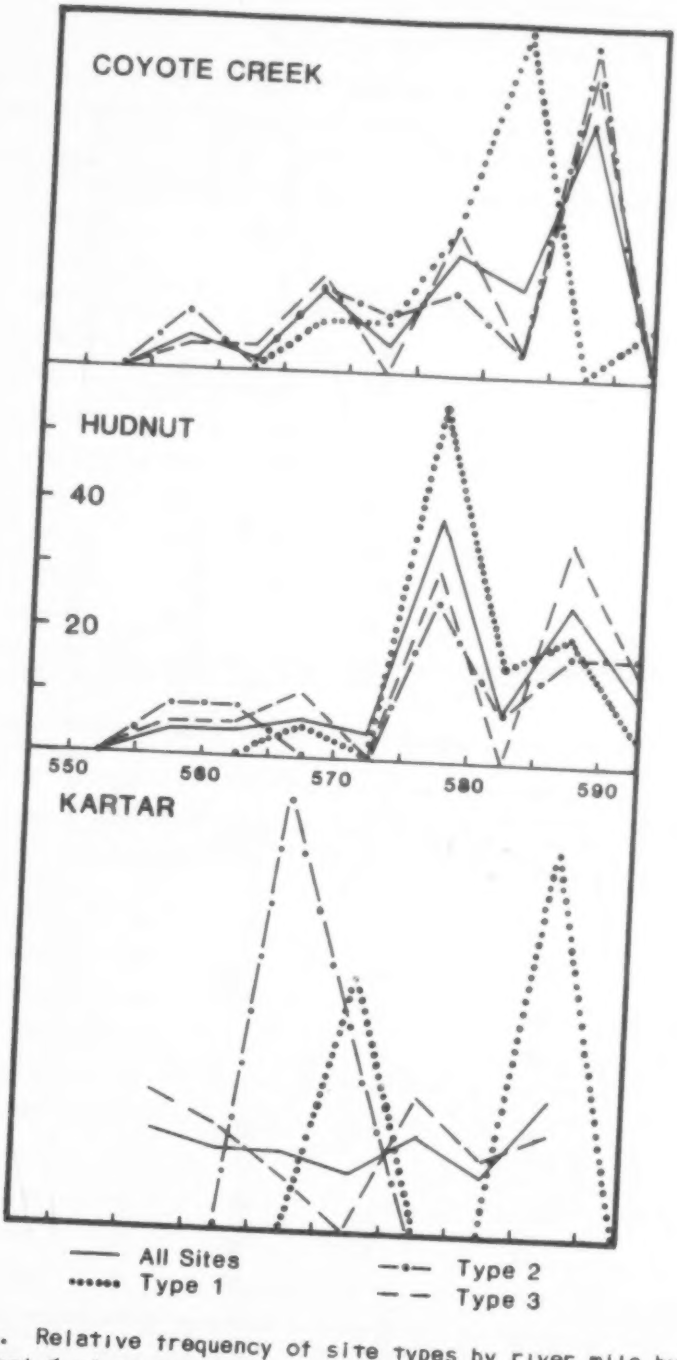

Figure 8-3. Relative frequency of site types by river mile by phase (shows what % of a given site type occurs in each reach).

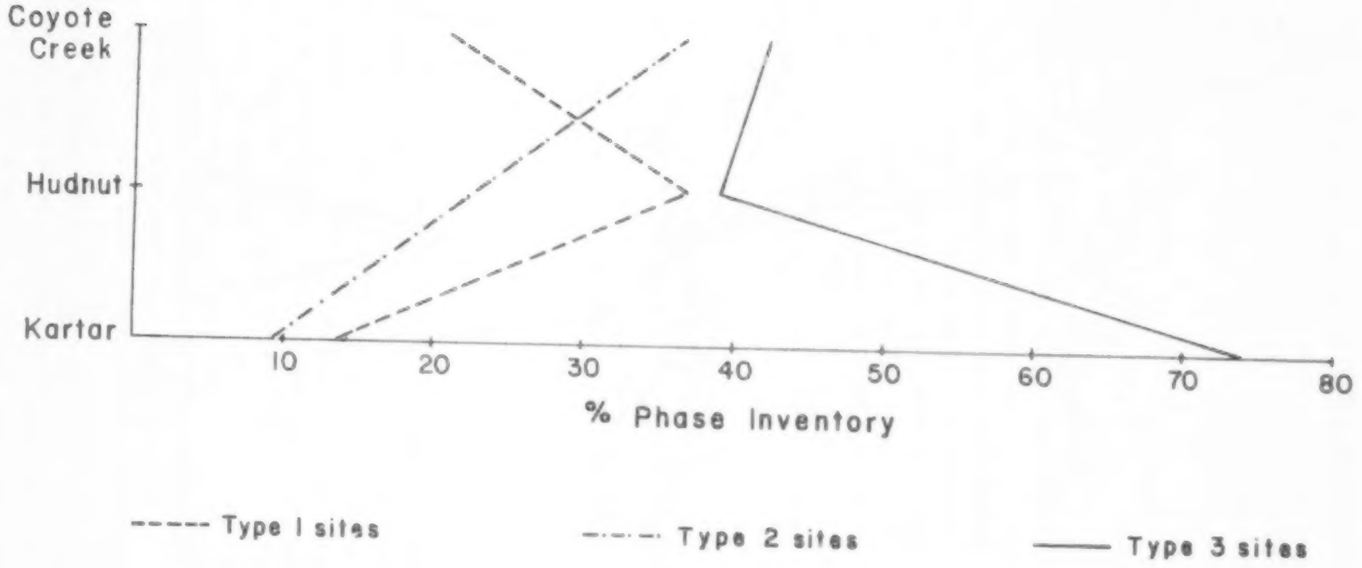

Figure 8-4. Relative frequency of site types by phase.

Table 8-7. Distribution of testing by reach.

Reach	River Mile	Number Tested[1]			% of Sites in Reach Tested		
		Housepit	Open Camp	All	Housepit	Open Camp	All
1	545-550	–	–	–	–	–	–
2	550-555	–	–	–	–	–	–
3	555-560	–	9	9	–	33	32
4	560-565	–	3	3	–	38	33
5	565-570	2	8	10	25	30	26
6	570-575	2	8	10	29	67	53
7	575-580	11	12	23	69	63	66
8	580-585	8	9	17	66	50	57
9	585-590	5	18	23	56	60	59
10	590-595	2	3	5	18	25	22
All	545-595	30	70	100			

[1] From Jermann et al. 1978; Lyman 1976; Osborne et al. 1952; Chatters 1984 a and b; Bryant 1978; Maas 1982, 1983.

Table 8-8. Relationship of testing/salvage intensity to number of occupations.

Reach	River Mile	Inventory Sites	Number of Occupations[1]	Ratio of Occupations to Sites	Percentage of Inventory Tested	Percentage of Inventory Salvaged[2]
1	545-550	4	4	1.0	–	–
2	550-555	10	10	1.0	–	–
3	555-560	28	41	1.5	32	7
4	560-565	9	16	1.8	33	22
5	565-570	35	52	1.5	26	8
6	570-575	19	41	2.2	53	5
7	575-580	35	72	2.0	66	14
8	580-585	30	40	1.3	57	7
9	585-590	39	83	2.1	59	10
10	590-595	23	27	1.2	22	–
All	545-595	232	386	1.7	43	8

[1] Untested/salvage sites tallied as 1; actual count for tested/salvaged sites. Sources: Jermann et al. 1978; Lyman 1976; Osborne et al. 1952; Chatters 1984 a and b; Bryant 1978; Maas 1982, 1983.

[2] Sources Chatters 1984a; Campbell 1984; Jaehnig 1983; 1984a and b; Lohse 1984a-f; Miss 1984a-d.

Table 8-9. Cluster radiocarbon dating control.

Cluster	Site Type	Total	Number of Radiocarbon Dates	Percentage Dated Assemblages	Comments
KA	1	2	1	50	
	2	3	1	33	
	3	11	2	18	
KB	1	3	3	100	
	2	0	0	-	1 date from mixed assemblage
	3	12	2	17	
HA	1	0	0	-	
	2	2	2	100	1 date from mixed assemblage
	3	2	2	100	
HB	1	1	1	100	
	2	2	1	50	
	3	2	2	100	
HC	1	14	7	50	
	2	4	1	25	
	3	6	1	17	
HD	1	5	5	100	
	2	4	1	25	
	3	10	3	33	
CA	1	0	0	-	
	2	2	2	100	
	3	2	1	50	
CB	1	2	2	100	
	2	5	3	60	
	3	4	0	-	
CC	1	10	9	90	
	2	4	3	75	
	3	7	2	29	
CD	1	1	0	-	
	2	12	9	75	
	3	13	9	69	

Table 8-10. Radiocarbon date ranges associated with clusters.

Phase	Cluster	Date Range[1] by Site Type			
		All	1	2	3
Coyote Creek	A	100-1300	No dates	100-800	850-1300
	B	500-1400	700-1400	700-900	500-800
	C	100-1600	100-1600	200-900	200-1500
	D	200-1900	No dates	600-1700	200-1900
Hudnut	A	2900-3800	No dates	3000-3400	2900-3800
	B	2800-3900	2900	2800-3900	2800-3500
	C	2100-4000	2100-3900	3900-4000	3100
	D	2000-4000	2300-3600	2500	2000-4000
Kartar	A	4200-5600	4200-5400	ca. 5000	5600
	B	4400-5500	4500-5500	No dates	4400-5500

[1] Based on available radiocarbon dates (dendrocorrected after Damon et al. 1974) rounded to the nearest 100.

store overwintering foods during the Kartar Phase probably was limited in comparison to later periods. The high proportion of Type 3 sites suggests a greater reliance on foraging during the Kartar Phase, unless we misread the signature of a field camp for this phase.

The Hudnut phase represents a local population roughly double that of the Kartar Phase. The occupations focus on the Hudnut Canyon and Belvedere areas. Housepit sites are dispersed widely over the study area, in the most even dispersion of all phases, suggesting that they served as a locus for activities that could be expected at both field and base camps. The winter range for ungulates along the river probably increased during a late mid-Holocene moister/cooler episode allowing more frequent wintering on the south side of the river. The more even proportions of site types per cluster suggests a somewhat more logistical economic system than that of the Kartar Phase, but not like that of the Coyote Creek Phase.

The Coyote Creek Phase represents a population slightly larger than that of the preceding Hudnut Phase. Houspit site dispersion is comparatively restricted, and limited to the north bank. They appear to focus on the area near the Nespelem River, an area ethnographically known for weir and trap salmon fishing. It is interesting to note that only for this phase do the locational data suggest a siting bias toward such areas. The sampling bias problem induced by the reservoir may be a particular problem to credibility of this observation, however, as the Coyote Creek occupations tend to occur on the lowest terraces, which were the first to be inundated when the reservoir was impounded. Aerial photogrammetry has shown a series of housepit sites on lower terraces in the lower reaches of the reservoir near Parsons Rapids that may have been a Coyote Creek Phase cluster (Appendix E). However, the Parson's Rapids vicinity has several good locations for weir and trap fishing, and if there were a Coyote Creek cluster, the principal observation that Coyote Creek Phase economy focused on salmon fishing would receive added support. If ethnographic sources are reliable, there probably was also a major Coyote Creek-aged community in the Belvedere vicinity, but the archaeological data to confirm this are unlikely to be recovered as they are either destroyed by residence and highway construction or covered by tons of excavation spoils from the third powerhouse at Grand Coulee Dam. The Coyote Creek Phase shows the highest per cluster site density and the most even spread of site types. It appears to represent a strongly logistical economic system.

The locational dimension of phase characteristics suggests that the settlement/subsistence system of the Kartar Phase was the least logistically organized and that of the Coyote Creek Phase the most. However, other dimensions of the archaeological record should also be considered in interpreting the economic organization of each phase. In particular, the question of what comprises a base, field and locational site at any given time is important, as these site types need not be denoted by the same criteria in each phase.

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9. SITE FREQUENCY, INTENSITY OF USE, AND DIFFERENTIATION THROUGH TIME

by Christian J. Miss

Our study of the past, whether emphasizing history or process, requires chronological ordering of data. By this means we can recognize change when it occurs and begin to seek explanation. Several systems of period and phase designation have appeared over the years in publications and papers produced by CJDARP (e.g. Jermann et al. 1978; Lohse 1983; Jaehnig 1983; Leeds et al. 1981). All are based on radiocarbon dates and/or stylistic analogy to other regional chronologies. However, none of these temporal orderings was able to take into account all of the time-stratigraphic units, or analytic zones, from excavated sites because these were in the process of definition as each site was analyzed.

This paper presents an independent ordering of the zones based primarily on radiocarbon dates, whether of the zones themselves or of adjacent, bracketing zones. We have attempted to minimize our dependence on stylistic analogy to other chronologies of the Plateau to avoid tautological reasoning in examination of other data. Unfortunately, as will be seen in the following discussion, we cannot entirely escape stylistic analogy particularly when dealing with the oldest identified components from the Project. We consider site frequencies by both 500 and 1000-year periods, demonstrating the arbitrary effects of periodization. We also present volumetric data on major debris categories in relation to time and site types based on features and consider the implications of these data for reconstructing settlement patterns.

SITE FREQUENCY THROUGH TIME

Thirty-four sites originally were recommended for excavation by the Project. Site condition and probability of destruction were important factors; however, within these constraints an additional effort was made to achieve representation of temporal, functional, geographical, and topographical variability (Jermann et al. 1978:102-109). Based on survey and testing results, the selected sites were thought to contain 67 components representative of associations of these variables. Eventually 18 of the sites were excavated and 84 components defined.

Figure 9-1 shows the temporal spans represented by the components or analytic zones. The spans are based on radiocarbon dates and single standard deviations (solid lines) and our "best guess" or relative methods of dating

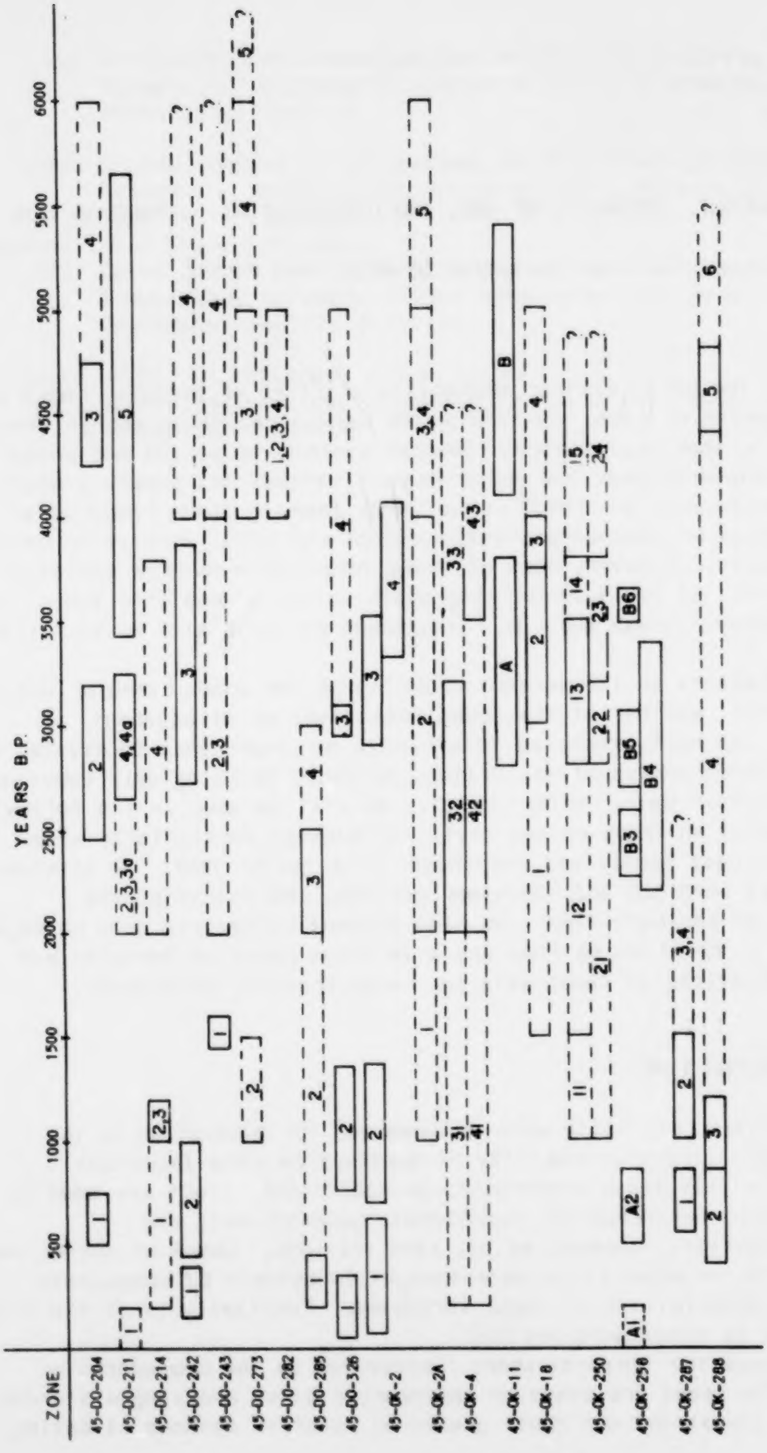

Figure 9-1. Temporal spans of analytic zones from project sites.

(broken lines). The ages of seven of the 36 radiocarbon dated components (19.4%) are based on single dates. The remaining zones have from 2 to 22 radiocarbon dates (Appendix D, Table D-4).

Figure 9-2 presents the number of components by 500-year span. Only components which were relatively securely dated and whose ages fell within a 500-year span were included. Thus, zones with single dates with excessively large standard deviations, i.e. greater than 500 years, were not included. Zones with mixed cultural deposits of disparate age also were not included.

Of immediate interest is the bimodality of the distribution, marked by the low frequency of zones from 1500 to 2000 B.P. and the absence of dates from 4000 to 4500 B.P. To increase the sample size to determine if these gaps are an artifact of the sample, we added 23 radiocarbon dated components defined by the Chief Joseph Dam Cultural Resources Project testing program (Jermann et al. 1978:Table 11) and recent excavations by Central Washington University in the River Mile (RM) 590 area (Chatters 1984b:Table 10). As Figure 9-3 shows, the additional data made the bimodal distribution even more pronounced; only two components have dates falling within the more recent span and no new components are added to the older. The components from additional excavations at 45-OK-196 and 45-OK-197 (Chatters 1984a) were not included. The components defined at 45-OK-196 are not dated finely enough to assign to 50-year periods. The components at 45-OK-197 are so finely divided they are noncomparable to other components: nineteen components span the period from 200 B.P. to 1950 B.P. The distribution of the components as defined would simply reinforce the pattern already apparent in Figure 9-3: 1 component is from the interval 200-500 B.P., 6 from 500-1000 B.P., 9 from 1000-1500 B.P. and 3 from 1500-2000 B.P.

As can be seen in Figure 9-1 several components are estimated to span the earlier period from 4000 to 4500 B.P. and radiocarbon dates are not completely absent. Five dates from 45-OK-11 and one from 45-OK-250 fall within the period. The frequencies in the preceding periods are somewhat misleading since they represent components that are most tenuously dated. Only 3 of the 9 components counted prior to 4500 B.P. are radiocarbon dated. There is a fourth component (which was not counted) from 45-DO-204 with two dates which straddles the arbitrary 4500 B.P. boundary. Only one of the components included in the period prior to 5000 B.P. was radiocarbon dated (45-OK-310). Five radiocarbon dates from 45-OK-11 and one from 45-DO-211 range from 5085±151 to 5497±142 B.P.

Whether the frequency of sites by 500-year periods reflects demographic variation or sampling bias is open to question. The project sample was restricted by the guide-taking lines to areas immediately adjacent to the river. Geologic analyses in the area and radiocarbon dates from excavation suggest most of the terraces tested by the project postdate 5000 B.P. Thus, low frequencies of sites at this end of the temporal range might be due to lack of landforms dating prior to about 5000 B.P. within the strictly defined boundaries of the project area. However, the Central Washington University testing project sampled higher terraces but no great expansion of the basic temporal framework under consideration resulted with the possible exception of

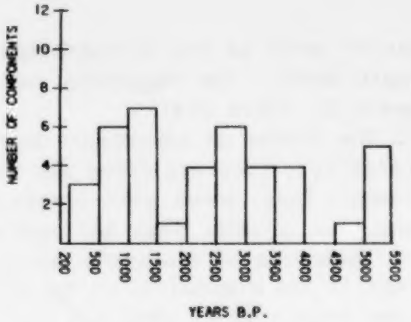

Figure 9-2. Number of components by 500-year periods.

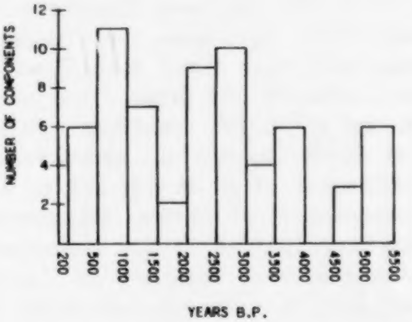

Figure 9-3. Number of components by 500-year periods including Chief Joseph Project testing components (Jermann et al. 1978) and RM 590 components (Chatters 1984b).

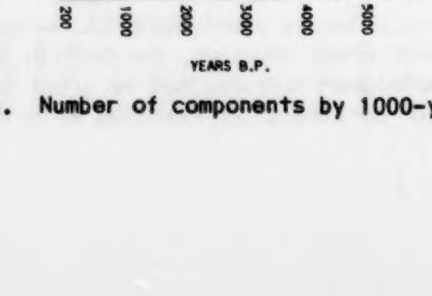

Figure 9-4. Number of components by 1000-year periods.

a single component capped by Mazama ash (Chatters 1984b). A comparison of the history of the landform on which 45-OK-11, which yielded most of the older radiocarbon dates, is located, with other landforms in the project area would illuminate the geologic processes affecting early habitation in the project areas.

An explanation for the more recent drop in frequency is less easily arrived at. We cannot state unequivocally that there are no occupations dating from 1500 to 2000 B.P., only that we have no dates. Chatters (1984b:120) noted a decline in the number of sites from 2500 to 1600 B.P. in the project area and suggested as potential explanations renewed downcutting by the river, population decline in response to sudden environmental change, or a shift in subsistence emphasis away from the river. Chance and Chance note increased density of artifacts at Kettle Falls and suggest an influx of people from the north, possibly prompted by a trend to moister environmental conditions about 2800 to 2600 B.P. (1982:408-9). They also suggest that a short drought about 1700 B.P. may have affected anadromous fish runs, at least at Kettle Falls, and been responsible for a substantial change in the archaeological culture there (Chance and Chance 1982:424).

Figure 9-4 presents the components arranged by 1000-year periods. Only cultural analytic zones from the CJDARP excavations are included because we lack volumetric data from other sources. The distribution is strongly unimodal with the 1500 to 2000 B.P. low obscured by the higher frequency of the later, adjacent period.

DENSITY OF MATERIAL CATEGORIES

In the subsequent discussion we use 1000-year intervals as the comparative time spans. Although this procedure decreases the precision of the analysis, we found it necessary for several reasons. First, the zones are not necessarily single, short-term occupations. They are stratigraphically correlated units of the same general age and may span more than 500 years. The larger periods allow us to include more components in our sample and to make statistical comparisons among the sub-groups. Second, we have made no correction for the carbonized material used for dating. Thus, the date derived from a piece of 300-year old Douglas fir might be a good deal different from that of a sagebrush branch burned at the same time. Third, a 1000-year period is likely to include two standard deviations of our dates making our age estimates more reliable.

MATERIAL DENSITIES THROUGH TIME

We have examined the volumetric data for the major debris categories of lithics, bone, shell, and fire-modified rock (FMR) in two ways. The first is a consideration of the count per cubic meter. The second is an attempt to take into account the variable time spans represented by the zones by calculating the number per cubic meter per year, using actual dates for year counts. The resulting figure is a rough measure of the rate of accumulation.

Figure 9-5 presents the cumulative mean frequency of the debris categories over time. Figure 9-6 similarly presents the cumulative mean accumulation rate of the debris categories by 1000-year period over time. Each shows bone to be the most common artifact. The frequency of lithics is more similar to that of bone in terms of simple density while rate of accumulation associates it with shell and FMR. Both graphs show consistent densities and rates of accumulation among the periods for bone, lithics, and FMR as evidenced by the slopes of the lines after 4000 B.P. Shell density and rate of accumulation increase in the 2000 to 3000 B.P. period and are lower before 4000 B.P.

Table 9-1 presents results of t-tests among the mean densities of the 1000-year periods. The greatest numbers of significant differences occur before 4000 B.P. and the contrast is even more pronounced before 5000 B.P. In general the mean densities for the components in these periods are much lower (Appendix D, Table D-2). Most of the cultural deposits are composed largely of lithics or lithics and bone fragment: FMR are rare and shell even more so. The extent to which these deposits may have been affected by erosion and redeposition is uncertain. Although field observations indicate that some are lag deposits, we do not believe this is a ubiquitous problem. We would expect lag deposits to have higher proportions of heavy materials such as FMR and lower proportions of lighter materials such as bone. The differences in shell density between the 2000-3000 B.P. period and the following two periods and between the 1000-2000 B.P. and 3000-4000 B.P. periods are of note. The mean density for the 2000-3000 B.P. span (1.64 per cu.m, s.d.=0.97) is the largest among the periods followed by the 3000-4000 B.P. span (1.49 per cu.m, s.d.=1.01). The lowest densities are found in the two most recent periods (0.68 per cu.m, s.d.=0.85 and 0.54 per cu.m, s.d.=0.58).

Table 9-1. Significance of differences[1] in mean densities of debris categories by 1000-year period.

Years B.P.	1-2000	2-3000	3-4000	4-5000	>5000
	L B S F[2]	L B S F	L B S F	L B S F	L B S F
200-1000	- - - -	- - + -	- - - -	- - - +	+ + 0 +
1-2000		- - + -	- - + -	- + - -	+ + 0 +
2-3000			- - - -	- + + +	+ + 0 +
3-4000				- + + +	+ + 0 +
4-5000					+ - 0 -

[1] Key to significance information: + = significant at 0.01 level; one-tailed probability; - = not signficant; 0 = too few scores to compute. Scores ≤ 1 object/m^3 counted as 0.

[2] Key to debris categories: L = Lithics; B = Bone; S = Shell; F = FMR

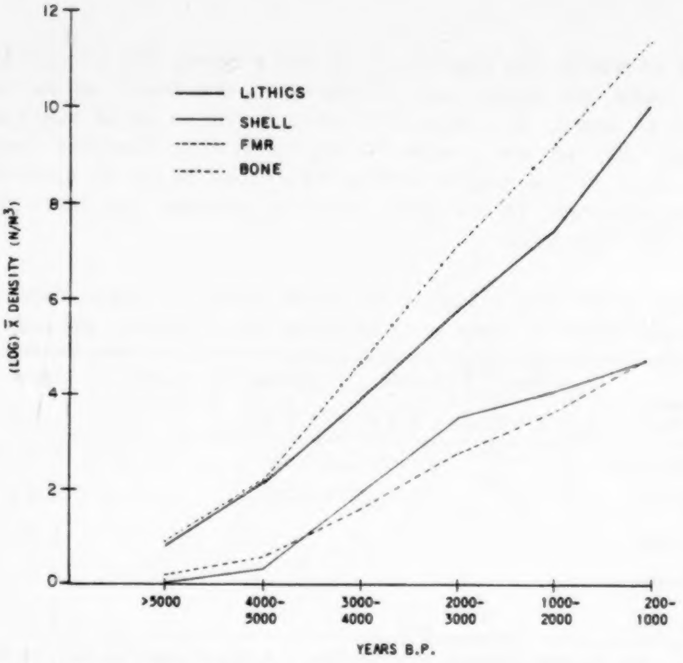

Figure 9-5. Mean density of debris categories by 1000-year periods.

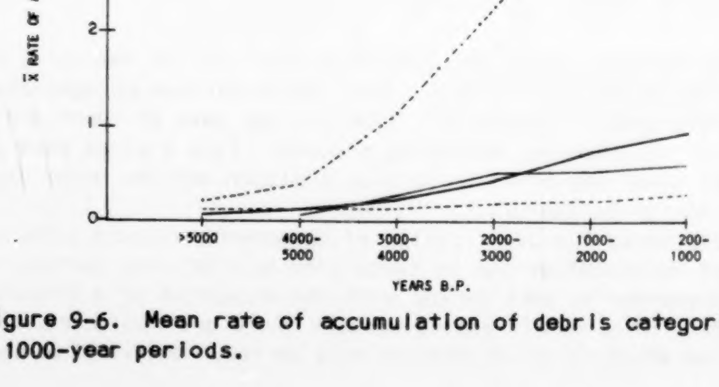

Figure 9-6. Mean rate of accumulation of debris categories by 1000-year periods.

Table 9-2 presents the results of t-tests among the groups for rates of accumulation. Here the significant differences are fewer as we take into account number of years, although with only a single value available for the span before 5000 B.P. we are unable to statistically evaluate the period. Again we find most of the significant differences prior to 4000 B.P. The other remaining contrast is for shell density between the 1000-2000 B.P. and the 2000-3000 B.P. periods.

Table 9-2. Significance of differences[1] in mean rate of accumulation of debris categories by 1000-year periods.

Years B.P.	1-2000	2-3000	3-4000	4-5000	>5000
	L B S F[2]	L B S F	L B S F	L B S F	L B S F
200-1000	- - - -	- - - -	- - - -	- - - +	0 0 0 0
1-2000		- - + -	- - - -	- - - -	0 0 0 0
2-3000			- - - -	- + + +	0 0 0 0
3-4000				- - - -	0 0 0 0
4-5000					0 0 0 0

[1] Key to significance information: + = significant at 0.01 level; one-tailed probability; - = not signficant; 0 = too few scores to compute. Scores ≤ 1 object/m^2 counted as 0.

[2] Key to debris categories: L = Lithics; B = Bone; S = Shell; F = FMR.

On the basis of this data alone, we might suggest a shift in subsistence emphasis at about 3000 B.P. to include more river mussel utilization, perhaps in response to environmental changes. Or, invoking an ethnographic analogy (Ray 1932), we might suggest less winter-time use of the riverine setting as evidenced by a decrease in the use of river mussels in the last 2000 years. The latter suggestion would also involve a restructuring of the subsistence round possibly in response to environmental or technological factors.

COMPARISON OF SITE TYPES

If we add another dimension, component type, to our analysis, the situation is not so straightforward. Each component was categorized according to criteria discussed in Chapter 6. Type 1 sites have at least one structure floor and one other feature, excluding middens. Type 2 sites have a living surface and at least one other feature or a midden and one other feature; Type 3 sites have one or no features.

Figure 9-7 shows the distribution of components in each site type for which rates of accumulation can be calculated by 1000-year period. All site types are represented in each period with the exception of a structure floor before 5000 B.P. This is misleading because there are radiocarbon dated structures from 45-OK-11 which date to this period. However, we have chosen

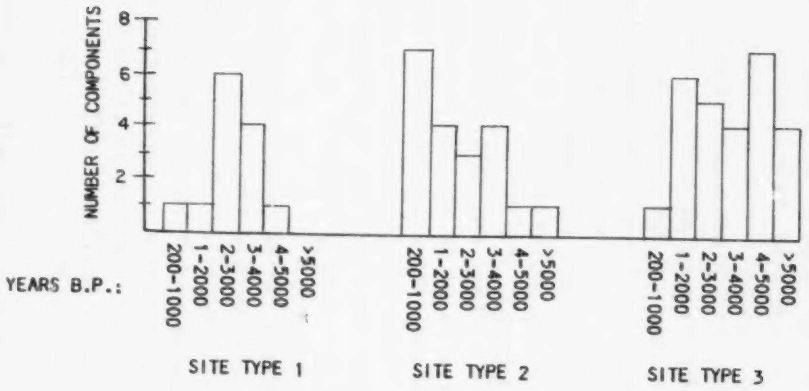

Figure 9-7. Component types by 1000-year periods.

to count this component in the 4000-5000 B.P. period because most of it is represented by this span (Figure 9-1). Subdivision of the component may be possible, but was not undertaken for this analysis.

Type 1 sites are most frequent from 2000 to 4000 B.P. and Type 2 sites increase through time (Figure 9-7). The Type 3 components are fairly common through time except for their low occurrence in the most recent period. Since they represent site use which left little in the way of structured remains, their functional significance is uncertain. They may represent transitory use or we may simply not have excavated them sufficiently to determine their nature.

The mean densities and rates of accumulation of materials are shown by site type in Figures 9-8 and 9-9. This casts a different light on our earlier question about a shift in subsistence practices in the 2000 to 3000 B.P. period based on evidence from river mussel shell. It seems the significant differences may be a function of site type. The greatest number of Type 1 components is found in this and the preceding period. Further, this type of component is associated with the greatest densities of all the material categories including shell (Figure 9-8). The first two periods (5-4,000 and 4-3,000) are dominated by Type 2 components with generally low material densities. The rates of accumulation (Figure 9-9) show differences among the component types, although not statistically sigificant ones, in the rate of accumulation for bone and shell and fairly consistent rates for lithics and FMR. The resulting conclusion is not too surprising: high densities of all material classes are associated with the Type 1 components resulting from intense use of faunal resources perhaps over a longer period of time and probably by more people. We might easily predict that energy would not be invested in the construction of a housepit or structure if it were not to be a significant focus of activity.

The Type 2 components can be regarded as camps, some with specific procurement focus, others representing short term residential sites with a variety of activities. Specialized focus is suggested by the greater, although not statistically significant, rate of lithic accumulation for these components. This we can construe as representing more lithic procurement and manufacture. Examination of frequencies of raw material types might indicate use of more of the casually acquired quartzites from river cobbles and manufacture of opportunistic tool types for these components than at the Type 1 locations.

Frequencies of features by component type also suggest specialization and residential use among the Type 2 components (Table 9-3). Most kinds of features are found with each component type. The association of Type 1 components with earth ovens and external hearths suggests a variety of activities with seasonal variation rather than winter hibernation in pit houses by the river as expected from the ethnographic accounts. Type 2 components are defined primarily by the presence of middens rather than well defined living surfaces. Earth ovens are more common here as are caches and hearths, and pits are well represented. Earth ovens suggest specialized food processing. Caches and pits suggest storage and site re-use. Comparison

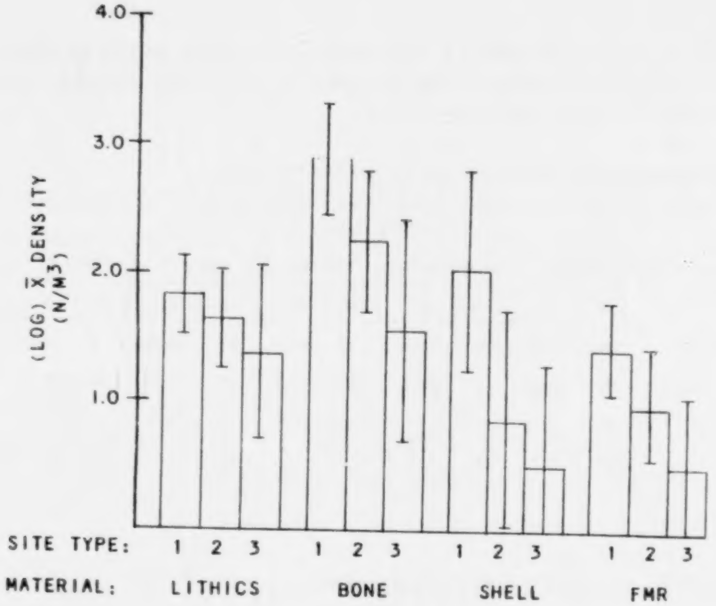

Figure 9-8. Mean density of debris categories by site type.

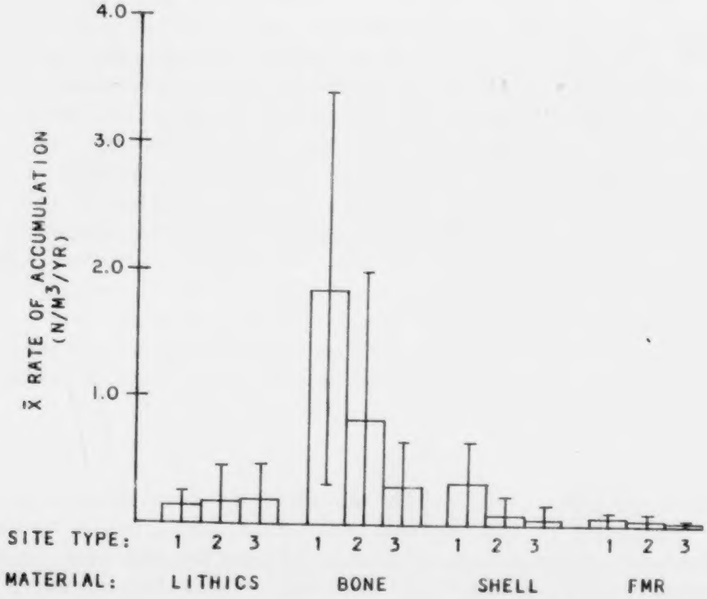

Figure 9-9. Mean rate of accumulation of debris categories by site type.

among the site types of the debris included in middens would probably show more shell in the Type 1 middens and primarily, although not exclusively, bone fragments and FMR in the Type 2 middens.

Table 9-3. Frequency of feature types by site type.

Site Type	Feature Type													
	Living Surface		Midden		Earth Oven		Hearth		Pit		Cache		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1	4	57.1	99	56.6	3	37.5	18	32.1	31	66.0	-	——	155	52.2
2	3	42.9	60	34.3	5	62.5	34	60.7	15	31.9	4	100.0	121	40.7
3	-		16	9.1	-		4	7.1	1	2.1	-		21	7.1
Total	7		175		8		56		47		4			

MATERIAL DENSITIES BY COMPONENT THROUGH TIME

Figures 9-10 and 9-11 present mean densities and rates of accumulation by 1000-year periods for the three component types. The data show similar densities with overlapping standard deviations over time for each component type. The rates of accumulation are more variable and not quite so clear in their meaning. Mean figures for the Type 1 components are limited to the two periods from 2000 to 4000 B.P. where rates of accumulation for all of the debris categories are not significantly different between the two spans. The rates of accumulation for the Type 2 components show differences that are statistically significant. The period from 1000 to 2000 B.P. shows higher accumulation rates for lithics, bone, and FMR than in the earlier periods. The accumulation rates for shell have large standard deviations in the earlier periods which overlap that of the later, but the mean value of the 1000 to 2000 B.P. period is much lower. While we caution that the numbers of components used for these calculations are low (Figure 9-7), the figures may indicate a trend in settlement pattern when considered in conjunction with the distribution of component types over time. On the basis of this data alone, there appears to be a trend toward fewer components with structures and a concomitant increase in intensity of use of open camp locales after 2000 B.P.

DISCUSSION

Our analysis has considered a limited array of data using shorter time intervals than customary in the region. Variation measured in terms of density and rates of accumulation of debris categories has been shown to be related more closely to site type than to time. There is, however, variation in both numbers of components and types of components over time. Two sharp lows in the distribution of the number of components occur. The earliest,

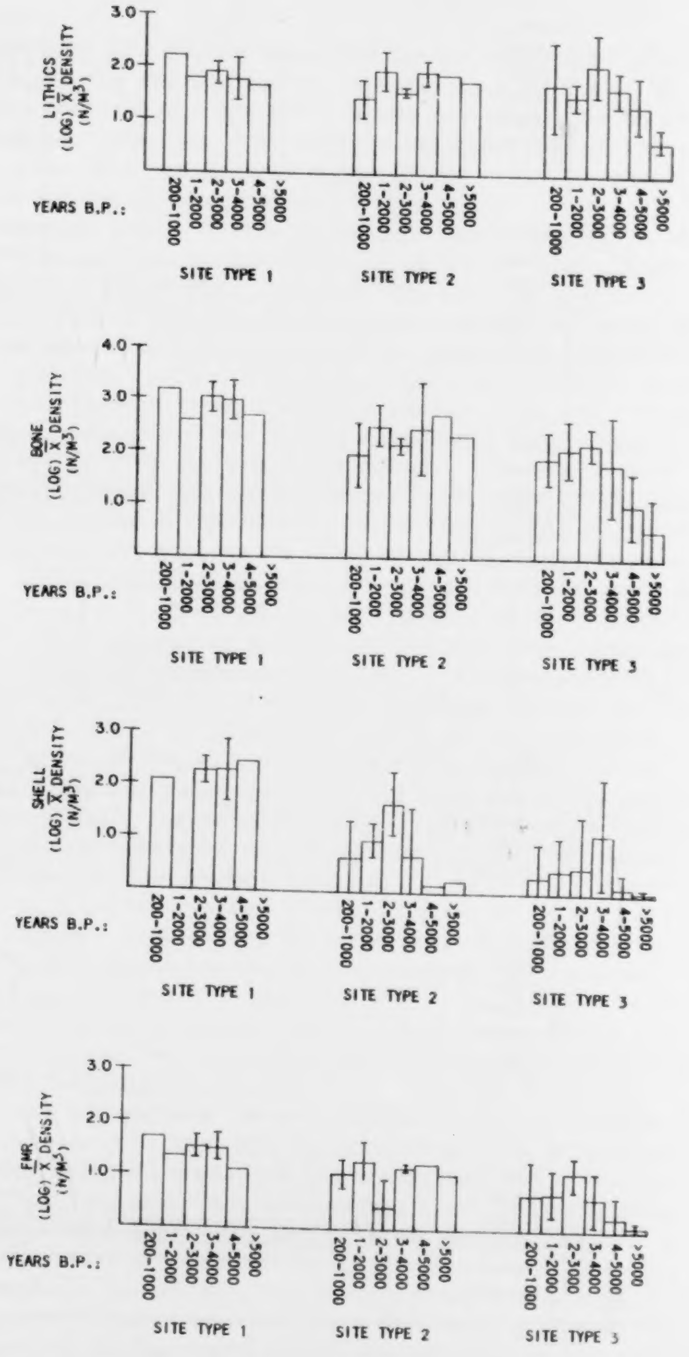

Figure 9-10. Mean density of debris categories by site type and 1000-year periods.

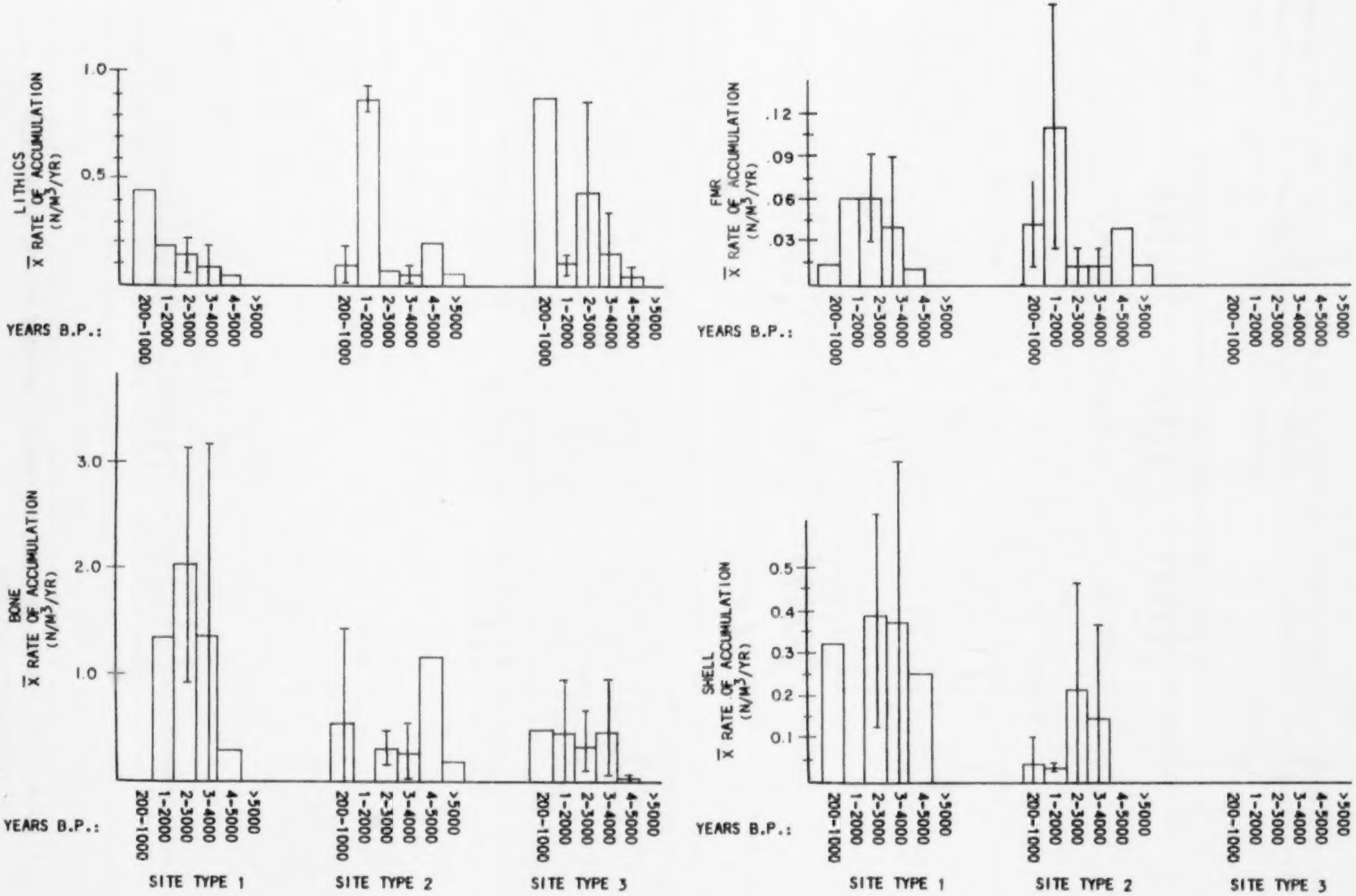

Figure 9-11. Mean rate of accumulation of debris categories by site type and 1000-year periods.

from 4000 to 5000 B.P. may be explained by the geological history of the project area and the restriction of investigation to the guide taking lines of the secondary pool raise. The more recent low from 2000 to 1500 B.P. is less easily explained. Numerous components were identified in the time spans before and after this one so that a geological event so selective as to affect only this period seems less likely.

Other changes occur at about 2000 B.P. Components with structures increase in number from the earliest, 45-OK-11, at about 5000 B.P., to become the most common type between 2000 and 3000 B.P. Up until 2000 B.P. the frequencies of Type 1 and Type 2 sites are similar, but after this point, the number of components with structures drops sharply and the number of Type 2 components increases. While densities remain fairly consistent for the component types through time, the accumulation rates for lithics, bone, and FMR suddenly increases for the Type 2 components after 2000 B.P.

It is difficult to explain these changes. The short term interruption of the anadromous fish run posited by Chance and Chance (1982:407) to account for an interruption in use of the Kettle Falls fishery amounting to a generation or two might plausibly account for lack of dates over a 500-year period, the smallest chronological unit we have attempted. However, such an event cannot explain the changes in component type frequency after 2000 B.P.

The data also contradict settlement pattern interpretations in the most recent model proposed for the upper Columbia (Chatters 1984b). In general we find the time spans used for the model too broad and the interpretation of cultural patterns tied too deterministically to environmental change. A closer examination of the effect of relatively "warmer, drier" or "cooler, moister" conditions on the actual carrying capacity of the surrounding area is needed. While broadly correct and probably applicable to the Columbia Plateau in general, such correlations do not adequately describe actual changes in the local environment of the project area and its environs. The project area differs from much of the Plateau in its location at an ecological and topographic boundary providing great diversity of floral communities and species habitats; resources could be sought from the river valley, the Columbia Plateau, and the Okanogan Highlands. We expect more flexibility in response to environmental change than in other areas of the Plateau; in fact, this diversity may be reponsible for the impression of conservative cultural development in the project area.

Only two of the periods defined by Chatters are discussed here. The period from 4700 B.P. to 2500 B.P. is associated with a settlement pattern of single, briefly occupied housepits and nonresidential sites initially used for opportunistic hunting and plant processing, later becoming specialized for these purposes (1984b:118). The period from 1600 to 200 B.P. is characterized as having multiple structure residential sites where housepits were re-used, fishing encampments and briefly occupied hunting and game processing sites. Presumably people lived in smaller, more dispersed groups in the earlier period, frequently moving their winter residences. In the later period the trend was toward larger population aggregates during the winter with seasonal dispersal into task groups to specialized food collecting sites (1984b:120).

Project data show a continuum of sites with multiple structures, repeated occupation, and intense use, from 5000 B.P. to 2000 B.P. Our earliest evidence from 45-OK-11 suggests that this was not a sudden innovation, but a continuation of a well established mode of living. Before 2000 B.P. components are more likely to have several structures than a single one (Table 9-4). Sheer quantities of associated debris and numbers and kinds of features as well as evidence of re-use of structures at 45-OK-4, 45-OK-11, 45-OK-250, and 45-OK-258 suggest regular intensive use by minimum bands occupying several structures contemporaneously, rather than infrequent highly variable use by small, single household units. Lohse (1984) has discussed the probable social structure associated with the early use of 45-OK-11 and suggests a pattern similar to that postulated for the more recent period. We suggest that a pattern of task groups using the structure clusters as central bases throughout the year and of specialized secondary sites is longstanding.

Table 9-4. Number of structures by 1000-year periods.

Years B.P.	Number of Structures						# Components with Structures	# Structures	Structures/ Component
	1	2	3	4	5	13			
200-1000	1	-	-	-	-	-	1	1	1.0
1-2000	1	-	-	-	-	-	1	1	1.0
2-3000	3	1	-	1	1	-	6	14	2.3
3-4000	1	1	2	-	-	-	4	9	2.2
4-5000	-	-	-	-	-	1	1	13	13.0
>5000	-	-	-	-	-	-	-	-	-
Total	6	2	2	1	1	1	13		
Row %	46.2	15.4	15.4	7.7	7.7	7.7			
Total # Structures	6	4	6	4	5	13		38	

We have noted the increase in the number of Type 2 components after 2000 B.P. with greater rates of material accumulation, implying more intense use of these locations by larger task groups or for longer periods of time. From these data it appears that the number of Type 1 structure components decrease as do the number of structures per component (Table 9-4). However, if we add data from 45-OK-2's first and second components which date from Euroamerican contact to about 1400 B.P., the pattern approaches that of the model. The two components contribute 11 structures to our tabulation. The second component includes 8 of these and suggests a larger aggregation of people. The low numbers of Type 1 components after 2000 B.P. may also be accounted for if locations of settlement actually shifted to exposed river bars as suggested by Chatters (1984b:119) and to the most recent terraces closest to the river. In this case we are faced with general destruction of the sites by reservoir impoundment.

CONCLUSIONS

This analysis has examined some very general data and suggested possible interpretations. Its greatest value is in questions it raises and the chronological discrimination it offers. We examined site frequency data by two different time intervals, 500 and 1000-year periods. Two distinct minima were noted when the finer time periods were used; only one of these was apparent in the longer time intervals. We suggest examination of specific kinds of data developed by the botanical, faunal, feature, geological, and stylistic projectile point analyses in terms of the smaller units of time defined above. In addition there is a wealth of data from the project which is applicable to numerous research questions and which could be used to clarify our understanding of the past and move our explanations beyond correlation with large scale climatic change, technological innovation, or subsistence discoveries.

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SECTION IV: THE ASSEMBLAGES

Chapters in this section describe in detail assemblages of specific kinds of materials collected from the archaeological components whose time/space distribution was considered in the preceding section.

Chapter 10, by Campbell, covers selected aspects of the artifact assemblages, apart from the distribution of functional types among the site types and periods, considered by Salo in Chapter 6. The bulk of the chapter is an analysis of lithic material types focussing on their proportions in different site types through time. This simple analysis, using only a small portion of the technological information available, shows that even this very basic level of data provides useful inferences about site differentiation and the organization of the settlement pattern in different time periods. The evidence for specialized fishing technology and the temporal distribution of imported marine shells is also briefly considered.

Lohse reports the stylistic analysis of projectile points in detail in Chapter 11. He concentrates primarily on projectile points as they are used as chronological markers, although the transition from atlatl darts to arrow points is also discussed. This analysis is noteworthy because it results in the abstraction of numeric, replicable criteria for the characteristics of Plateau projectile point types as an aid in assigning projectile points to those types.

In Chapter 12, Livingston describes the faunal assemblage collected by the project. The first section indicates the frequency and condition of the different kinds of bones recovered and provides background information on habitat and behavior of the creatures represented. The interpretive section covers biogeography, paleoenvironmental interpretation, and issues in quantitative interpretation of this complex data. In particular, the discussions of how the MNI/NISP relationship varies with cultural practices, and how inferences about seasonality are affected by sample size, are essential to interpretation of faunal remains as indications of cultural subsistence practices.

A descriptive summary of botanical remains recovered from project sites is given by Stenholm in Chapter 13. Unlike lithics and bone, not all botanical remains from all sites could be collected, processed and identified, thus sampling biases potentially play a bigger role. The emphasis is therefore generally on qualitative descriptions rather than quantitative comparisons. This chapter is a landmark in Plateau archaeology because it is the first report of a large quantified assemblage of plant remains from anywhere in the region. Dr. Stenholm's pioneering efforts demonstrate the abundance and diversity of the botanical remains in open sites; show the potential for materials of great age and delicacy to be preserved; and suggest the potential interest of quantitative analysis of fuel wood.

Features are discussed in Chapter 14 by Sammons-Lohse. In the first section, houses and features associated with house interiors are described by phase and the contrasts in structure, organization, and associations are discussed. Exterior occupation surfaces and other exterior features are discussed in less detail in the following section. An outstanding aspect of this feature description is the use of density measures, systematically compiled for different material categories by phase and feature type. From the characteristics of features, particularly houses, the author makes inferences about social organization and population. These interpretations, independent of conclusions drawn from site distribution studies and site type comparisons in other chapters, make an important contribution to the report.

10. SELECTED ASPECTS OF THE ARTIFACT ASSEMBLAGE

by Sarah K. Campbell

This chapter is not a thorough descriptive summary of the artifact assemblage; rather, it considers selected aspects. The primary focus is on exploring the application of technological data to the interpretation of settlement patterns. The richness and character of functional artifact type assemblages by site type and phase are considered elsewhere, but one additional aspect of the functional data, fishing equipment, is considered here in more detail. Shell artifacts also are discussed; these consist largely of ornaments of imported marine shell that may be stylistically sensitive and provide indication of extra-regional trade.

TECHNOLOGIC VARIATION AMONG SITE TYPES AND PHASES

Just as we have certain expectations about inter- and intra-site functional diversity in logistical and foraging systems, so have we about technological variation among assemblages. Binford (1980) suggests that specialized equipment and facilities characterize collector technology in contrast to more generalized equipment used by foragers. Chatters (1984a) suggests that collectors would emphasize curated tools, and that these would be manufactured, repaired, recycled and discarded primarily at residential sites. At field camps and locations, these tools would merely be used, along with a variety of expedient tools.

The above assumptions lead us to several specific expectations about technologic variation among the site types and phases defined for the project area. If the subsistence/settlement pattern shifts from the forager end of the spectrum to the collector end, we would expect a more specialized technology through time; that is, we expect that the technology of the Kartar Phase would be the least specialized, that of the Coyote Creek Phase the most. At any given time, we would expect more opportunistic use of raw materials available in the immediate vicinity at field camps (Type 2 sites) and locations/stations (Type 3 sites) than at central bases (Type 1 sites). We expect the highest proportions of shaped tools and the greatest evidence for selectivity in material types at residential bases (Type 1 sites). (For details of site type definition, see Chapter 6). This chapter examines the distribution of material types and related rough technological measures to see if such a pattern is evident.

LITHIC MATERIAL TYPES

Nearly 40 separate lithic material types were recorded in project assemblages. Material categories were added in the course of analysis, thus not all material categories were applied to all sites. In this analysis of material frequencies by site type and phase, materials are grouped into inclusive categories which alleviate the biases created by changes in the recording system. These are local CCS (jasper, chert, chalcedony, opal), imported CCS (petrified wood, obsidian), basalt (including fine-grained), quartzite (including fine-grained), argillite and silicified mudstone (called silicized mudstone in other project reports), and other.

While I have termed jasper, chalcedony, and opal "local CCS" to contrast them with CCS materials not found in the project area, they are available primarily at the valley rims in basalt flows, not in the immediate vicinity of the sites along the river. Quartzite (some of which is actually a feldspathic schist) is immediately available near most of the sites, as it is found extensively in the Columbia River gravels. The coarse-grained variety, which breaks into tabular pieces along bedding planes, is by far the most common in the area. Analysis of assemblages at individual sites has shown that the fine-grained quartzite assemblage includes a higher percentage of conchoidal flakes and flake tools than the coarse-grained variety; nonetheless, both types of quartzite seem to have been used primarily to make tabular knives (Campbell 1984). Sources of basalt are widespread in the project area and beyond but vary in quality. It is not known if the basalt used in lithic reduction was extracted from the river gravels or more distant sources of higher quality. Fine-grained and other basalt have been grouped because the distinction is probably an arbitrary separation along a continuum with no particular cultural significance. Argillite and silicified mudstone, the only other materials used for the manufacture of stone tools in significant amounts, are tabulated as a separate category. Both may be available locally as rare components of the Columbia River gravels. However, both are found under circumstances suggesting they are imported--high proportions of shaped tools and few accompanying manufacturing products (Miss 1984b; Campbell 1984). The source is probably northeastern Washington, where these materials are more common.

The frequency of grouped material types by phase and site type is shown in Table 10-1. The sample sizes are quite large and even small percentage differences are likely to be significant. Looking first at phase totals (Table 10-2) we see a distinct increase in the percentage of local CCS materials from the Kartar to Coyote Creek periods, and a decrease in the proportions of quartzite, and basalt. These three categories together comprise over 90% of the assemblage in each phase. Imported CCS materials occur in similar proportions in Hudnut and Kartar Phase sites, but increase in the Coyote Creek period. The highest proportion of argillite and silicified mudstone is in the Hudnut Phase.

Table 10-1. Frequency of grouped material types by phase and site type[1].

Phase	Site Type	Local CCS		Imported CCS		Quartzite		Basalt		Argillite and Sil. Mudstone		Other		Total
		N	%	N	%	N	%	N	%	N	%	N	%	
Coyote Creek	1	49227	80.4	644	1.1	10326	16.9	583	1.0	250	0.4	176	0.3	61206
	2	28319	83.7	229	0.7	4080	12.1	716	2.1	157	0.5	333	1.0	33834
	3	16955	86.6	104	0.5	1301	6.6	338	1.7	307	1.6	131	0.7	19586
	All	94501	82.4	977	0.9	15707	13.7	1637	1.4	1164	1.0	640	0.6	114626
Hudnut	1	42939	73.5	249	0.4	12460	21.3	2087	3.6	287	0.5	414	0.7	58436
	2	24650	70.5	204	0.6	5229	15.0	4211	12.0	307	0.9	354	1.0	34955
	3	24712	79.1	118	0.4	2107	6.7	533	1.7	3594	11.5	180	0.6	31244
	All	92301	74.1	571	0.5	19796	15.9	6831	5.5	4188	3.4	948	0.8	124635
Kartar	1	12939	47.9	101	0.4	6472	23.9	6930	25.6	165	0.6	420	1.6	27027
	2	3127	63.3	27	0.5	916	18.6	212	4.3	527	10.7	128	2.6	4937
	3	7153	87.5	64	0.8	573	7.0	248	3.0	93	1.1	47	0.6	8178
	All	23219	57.8	192	0.5	7961	19.8	7390	18.4	785	2.0	595	1.5	40142

[1] Excludes mixed zones: 45-DO-211, Zone 5; 45-DO-282, Zone 5; 45-OK-2A, Zone 5; 45-OK-18, Zone 1; 45-OK-288, Zone 4.
Excludes historic zone: 45-DO-211, Zone 1.

Table 10-2. Comparison of material types by phase[1].

Phase	Local CCS %	Imp. CCS %	Qtzite %	Basalt %	Arg. & S. Mud. %	Other %	Sample Size %
Coyote Creek	82.4	0.9	13.7	1.4	1.0	0.6	114626
Hudnut	74.1	0.5	15.9	5.5	3.4	0.8	124635
Kartar	57.8	0.5	19.8	18.4	2.0	1.5	40142

1. See Table 10-1 for frequency data.

The overall trends generally are echoed within each site type (Table 10-3). Quartzite decreases through time at all site types; the decrease is least dramatic at Type 3 sites. Basalt decreases through time at residential (Type 1) and station/location (Type 3) sites, but at field camp (Type 2) sites it is higher in the Hudnut than in the Kartar Phase. The CCS materials offer the most surprising exception. While both local and imported CCS increase from the Kartar Phase to the Coyote Creek Phase in Type 1 and 2 sites, in Type 3 sites the highest proportions are found in the Kartar Phase and the lowest proportions in the Hudnut Phase.

Table 10-3. Comparison of material types by phase within site types[1].

Site Type	Phase	Local CCS %	Imp. CCS %	Qtzite %	Basalt %	Arg. & S. Mud. %	Other %	Sample Size
1	CC	80.4	1.1	16.9	1.0	0.4	0.3	61206
	H	73.5	0.4	21.3	3.6	0.5	0.7	58436
	K	47.9	0.4	23.9	25.6	0.6	1.6	27027
2	CC	83.7	0.7	12.1	2.1	0.5	1.0	33834
	H	70.5	0.6	15.0	12.0	0.9	1.0	34955
	K	63.3	0.5	18.6	4.3	10.7	2.6	4937
3	CC	86.6	0.5	6.6	1.7	1.6	0.7	19586
	H	79.1	0.4	6.7	1.7	11.5	0.6	31244
	K	87.5	0.8	7.0	3.0	1.1	0.6	8178

1. See Table 10-1 for frequency data.

In spite of the overall change in material proportions through time, the distribution of material types among the site types in each phase is surprisingly similar (Table 10-4). The highest proportions of quartzite are found in Type 1 sites and the lowest in Type 3 sites. The highest proportions of CCS are found in Type 3 sites and the lowest in Type 1 sites with one exception--in the Hudnut Phase the proportions at Type 2 sites are lower than at Type 1 sites. In both the Coyote Creek and Hudnut Phases, the highest relative frequency of basalt is in Type 2 sites, while in the Kartar Phase the highest relative frequency is at Type 1 sites. The distribution pattern of imported CCS materials is least similar among phases; the highest proportions in the Coyote Creek Phase are at Type 1 sites, in the Hudnut Phase at Type 2 sites, and in the Kartar Phase at Type 3 sites.

Table 10-4. Comparison of material types by site type within phases[1].

Phase	Site Type	Local CCS %	Imp. CCS %	Qtzite %	Basalt %	Arg. & S. Mud. %	Other %	Sample Size
Coyote Creek	1	80.4	1.1	16.9	1.0	0.4	0.3	61206
	2	83.7	0.7	12.1	2.1	0.5	1.0	33834
	3	86.6	0.5	6.6	1.7	1.6	0.7	19586
Hudnut	1	73.5	0.4	21.3	3.6	0.5	0.7	58436
	2	70.5	0.6	15.0	12.0	0.9	1.0	34955
	3	79.1	0.4	6.7	1.7	11.5	0.6	31244
Kartar	1	47.9	0.4	23.9	25.6	0.6	1.6	27027
	2	63.3	0.5	18.6	4.3	10.7	2.6	4937
	3	87.5	0.8	7.0	3.0	1.1	0.6	8178

1. See Table 10-1 for frequency data.

At first glance, the relative proportions of lithic materials among site types do not fit our expectations; the most readily available material, quartzite, is found in highest proportions at central bases (Type 1 sites) where we expected to have evidence of the greatest selectivity. However, we must be cautious in drawing conclusions from these distributions. Because we are looking at all lithic objects, cobble tools as well as flake tools and debitage are included. Also, we may be including more than one specialized flaking industry. A bipolar cobble reduction sequence aimed at producing tabular flakes and practiced almost entirely on quartzite is well documented in individual project site reports. Looking at the products of several different industries at once may introduce variability that obscures the predicted pattern in each individual industry.

In the following sections we look for the predicted pattern of specialization by holding either artifact class or material type constant and looking at the variation in the other, that is examining the proportions of material types among a certain artifact class, and the proportions of object types among a specific material type.

MATERIAL PREFERENCE FOR FLAKE TOOLS

In this section we limit the field to flake tools, and examine the the variation in the material types from which they are made at different site types in each phase. I have grouped flake tools into three categories: shaped flakes (projectile points, drills, gravers, scraper, spokeshaves); retouched flakes (bifaces, bifacially retouched flakes, and unifacially retouched flakes); and utilized flakes (Table 10-5). As discussed elsewhere (Campbell 1984:106, 119, 124) the categories biface, bifacially retouched flake and unifacially retouched flake include fragments of shaped tools, manufacturing debris, and partially shaped flake tools. Thus, the retouched flake category may inform more about manufacturing than about use. At any rate, the retouched flake category generally represents less energy investment than finished shaped tools, and more than utilized flakes.

A distinctive pattern is apparent among phases in the proportions of material types comprising the above categories of flake implements (Table 10-6). Comparing totals by phase, we see that for each category of flake tools--shaped, retouched, and utilized--the proportion made of CCS increases from the Kartar to the Coyote Creek period. Therefore, even controlling for particular categories of tools, we find a distinct decrease in use of non-CCS materials and increase in use of CCS materials. This change could be due to a change in availability of materials, to a greater suitability of CCS for making the kinds of flake tools used, or to a change in mobility which changed the frequency of contact with different lithic sources.

Table 10-6. Comparison of material types by phase within flake tool categories[1].

Flake Tool Category	Phase	CCS	Qtzite	Basalt	Obsidian	Other	Total
Shaped Tools	Coyote Creek	94.7	0.2	3.0	0.3	1.8	1021
	Hudnut	90.9	0.3	6.1	0.2	2.4	864
	Kartar	84.3	6.0	8.5	0.3	0.9	318
Retouched Flakes	Coyote Creek	95.4	1.8	1.2	0.4	1.3	1710
	Hudnut	92.8	0.9	3.4	0.2	2.7	1306
	Kartar	85.9	7.4	5.4		1.4	503
Utilized Flakes	Coyote Creek	97.4	0.6	0.7	0.3	1.0	2130
	Hudnut	96.0	1.0	1.4	0.1	1.5	1495
	Kartar	92.9	1.9	3.3	0.1	1.8	830

1. See Table 10-5 for frequency data.

Table 10-5. Frequency of material types by flake tool category by phase and site type1.

Phase	Site Type	Shaped Tools						Retouched Flakes						Utilized Flakes					
		CCS	Qtzite	Basalt	Obsidian	Other	Total	CCS	Qtzite	Basalt	Obsidian	Other	Total	CCS	Qtzite	Basalt	Obsidian	Other	Total
Coyote Creek	1	479 95.8	1 0.2	10 2.0	1 0.2	9 1.3	500	868 95.2	25 2.7	9 1.0	1 0.1	9 1.0	912	954 98.6	3 0.3	5 0.5	2 0.2	5 0.5	969
	2	376 93.8	1 0.2	18 4.5	2 0.5	4 1.0	40	617 95.8	4 0.6	11 1.7	4 0.6	8 1.2	644	807 97.0	7 0.8	6 0.7	3 0.4	9 1.1	832
	3	112 93.3	-	3 2.5	-	5 4.2	120	147 95.5	1 0.6	-	1 0.6	5 3.2	154	313 95.1	2 0.6	4 1.2	1 0.3	9 2.7	329
	All	967 94.7	2 0.2	31 3.0	3 0.3	18 1.8	1021	1632 95.4	30 1.8	20 1.2	6 0.4	22 1.3	1710	2074 97.4	12 0.6	15 0.7	6 0.3	23 1.3	2130
Hudnut	1	486 91.7	1 0.2	32 6.0	1 0.2	10 1.9	530	616 95.5	6 0.9	17 2.6	-	6 0.9	645	696 96.9	7 1.0	7 1.0	-	8 1.1	718
	2	219 91.3	1 0.4	17 7.1	1 0.4	2 0.8	240	346 92.8	3 0.8	19 5.1	2 0.5	3 0.8	373	390 95.6	7 1.7	9 2.2	-	2 0.5	408
	3	80 85.1	1 1.1	4 4.3	-	9 9.6	94	250 86.8	3 1.0	9 3.1	-	26 9.0	288	349 94.6	1 0.3	5 1.4	2 0.5	12 3.3	369
	All	785 90.9	3 0.3	53 6.1	2 0.2	21 2.4	864	1212 92.8	12 0.9	45 3.4	2 0.2	35 2.7	1306	1435 96.0	15 1.0	21 1.4	2 0.1	22 1.5	1495
Kartar	1	129 81.1	6 3.8	23 14.5	1 0.6	-	159	201 82.7	11 4.5	29 11.9	-	2 0.8	243	164 90.6	4 2.2	12 6.6	-	1 0.6	181
	2	38 73.1	12 23.1	1 1.9	-	1 1.9	52	68 72.3	25 26.6	-	-	1 1.1	94	89 80.2	11 9.9	3 2.7	-	8 7.2	111
	3	102 94.4	1 0.9	3 2.8	-	2 1.9	108	163 92.6	1 0.6	8 4.5	-	4 2.3	176	518 96.3	1 0.2	12 2.2	1 0.2	6 1.1	538
	All	269 84.3	19 6.0	27 8.5	1 0.3	3 0.9	319	432 85.9	37 7.4	27 5.4	-	7 1.4	503	771 92.9	16 1.9	27 3.3	1 0.1	15 1.8	830

[1] Excludes mixed zones: 45-DO-211, Zone 5; 45-DO-282, Zone 5; 45-DO-326, Zone 4; 45-OK-2A, Zone 5; 45-OK-18, Zone 1; 45-OK-288, Zone 4.
Excludes historic zone: 45-DO-211, Zone 1.

If we look at the distribution among site types in each phase (Table 10-7), the same general pattern is manifest for the Coyote Creek and Hudnut phases; CCS constitutes the highest proportion of all categories of flake tools in Type 1 sites and the lowest in Type 3 sites. The single exception is retouched flakes in the Coyote Creek Phase. In the Hudnut and Coyote Creek Phases basalt occurs in its highest percentages in Type 2 sites except in the case of utilized flakes in the Coyote Creek Phase, more often made of basalt at Type 3 sites than Type 2 sites. The proportion of quartzite is sometimes highest in Type 2 sites and sometimes in Type 3 sites, except for retouched flakes in the Coyote Creek Phase, a greater proportion of which are quartzite at Type 1 sites.

Although the sample from Kartar Type 2 sites is quite small, the data for the Kartar Phase sites clearly indicates a different pattern of distribution of material types. The CCS distributions are the exact reverse of those of the Coyote Creek and Hudnut Phases; the highest proportions of CCS are found in Type 3 sites and the lowest in Type 1 sites. The highest percentages of basalt flake tools occur at Type 1 sites and the highest percentages of quartzite at Type 2 sites.

These patterns suggest that in Hudnut and Coyote Creek Phases non-CCS materials were used opportunistically at field camps (Type 2 sites) and locations/stations (Type 3 sites) for making flake tools, whether shaped or simply used unmodified. If we assume that lithic manufacture at Kartar locations/stations (Type 3 sites) was also opportunistic, then we must conclude that CCS was a less preferred material, and was not selected to take back to the residential site. Alternatively, the Kartar locations/stations could have some specialized function which required CCS materials or brought the users into contact with CCS materials. For it appears that during the Kartar Phase, locations/stations were the loci of specialized lithic manufacture rather than opportunistic lithic reduction as expected. Other evidence supporting this interpretation is found in the variable occurrence of the microblade industry, discussed below.

SPECIALIZATION IN CCS USE

Another approach to measuring the degree of specialization in lithic manufacturing activities through time and at different site types is to hold material type constant, and examine the varying proportions of manufactured products among phases and site types. I chose CCS, the dominant material of the bifacial reduction industry in all phases, and the material with the largest sample sizes. Table 10-8 shows the proportions of shaped, retouched, and utilized flake tools, and tabular knives within the CCS assemblage in each phase and site type.

Table 10-7. Comparison of material types by phase and site type within flake tool categories[1].

Flake Tool Category	Phase	Site Type	CCS	Qtzite	Basalt	Obsidian	Other	Total
Shaped Tools	Coyote Creek	1	95.8	0.2	2.0	0.2	1.3	500
		2	93.8	0.2	4.5	0.5	1.0	40
		3	93.3		2.5		4.2	120
	Hudnut	1	91.7	0.2	6.0	0.2	1.9	530
		2	91.3	0.4	7.1	0.4	0.8	240
		3	85.1	1.1	4.3		9.6	94
	Karter	1	81.1	3.8	14.5	0.6		159
		2	73.1	23.1	1.9		1.9	52
		3	94.4	0.9	2.8		1.9	108
Retouched Flakes	Coyote Creek	1	95.2	2.7	1.0	0.1	1.0	912
		2	95.8	0.6	1.7	0.6	1.2	644
		3	95.5	0.6		0.6	3.2	154
	Hudnut	1	95.5	0.9	2.6		0.9	645
		2	92.8	0.8	5.1	0.5	0.8	373
		3	86.8	1.0	3.1		9.0	288
	Karter	1	82.7	4.5	11.9		0.8	243
		2	72.3	26.6			1.1	94
		3	92.6	0.6	4.5		2.3	176
Utilized Flakes	Coyote Creek	1	98.6	0.3	0.5	0.2	0.5	969
		2	97.0	0.8	0.7	0.4	1.1	832
		3	95.1	0.6	1.2	0.3	2.7	329
	Hudnut	1	96.9	1.0	1.0		1.1	718
		2	95.6	1.7	2.2		0.5	408
		3	94.6	0.3	1.4	0.5	3.3	369
	Karter	1	90.6	2.2	6.6		0.6	181
		2	80.2	9.9	2.7		7.2	111
		3	96.3	0.2	2.2	0.2	1.1	538

1. See Table 10-5 for frequency data.

Table 10-8. Frequency of CCS tool categories by phase and site type.

Phase	Site Type	Shaped Flake Tools		Retouched Flakes		Utilized Flakes		Tabular Knives		Total
		N	%	N	%	N	%	N	%	
Coyote Creek	1	479	20.8	868	37.7	954	41.4	3	0.1	2304
	2	376	20.9	617	34.3	807	44.8	1	0.1	1801
	3	112	19.6	147	25.7	313	54.7	–	–	572
	All	967	20.7	1632	34.9	2074	44.3	4	0.1	4677
Hudnut	1	486	27.0	616	34.2	696	38.7	1	0.1	1799
	2	219	22.9	346	36.2	390	40.8	–	–	955
	3	80	11.8	250	36.8	349	51.3	1	0.1	680
	All	785	22.9	1212	35.3	1435	41.8	–	–	3434
Kartar	1	129	26.1	201	40.7	164	33.2	–	–	494
	2	38	19.5	68	34.9	89	45.6	–	–	195
	3	102	13.0	163	20.8	518	66.2	–	–	783
	All	269	18.3	432	29.3	771	52.4	–	–	1472

In general, the proportion of shaped tools increases through time and the proportion of utilized flakes decreases (Table 10-9), suggesting manufacture of a more specialized tool kit through time. It is not, however, a linear trend; the highest proportions of shaped tools and retouched tools is in the Hudnut Phase.

Table 10-9. Comparison of CCS tool categories by phase[1].

Phase	Sh. Flakes	Ret. Flakes	Util. Flakes	Tab. Knives	Sample Size
Coyote Creek	20.7	34.9	44.3	0.1	4677
Hudnut	22.9	35.3	41.8	–	3434
Kartar	18.3	29.3	52.4	–	1472

1. See Table 10-8 for frequency data.

In spite of this general trend through time, the pattern of inter-site variation is similar among phases (Table 10-10). In each phase, the proportion of shaped tools is highest at residential (Type 1) sites and lowest at stations/locations (Type 3 sites), and the inverse pattern obtains for utilized flakes. This does not necessarily indicate that more shaped tools were being manufactured at Type 1 sites; they could be manufactured elsewhere and the proportions at Type 1 sites simply reflect the selectivity with which things were brought back. However, in both the Kartar and Coyote Creek Phases, the highest proportions of retouched flakes are found at Type 1 sites and the lowest at Type 3 sites suggesting that different kinds of manufacturing activities occurred. Retouched flakes in Hudnut Phase sites have the reverse pattern, being most common at Type 3 sites and least common at Type 1 sites. The proportions at all three type sites are very similar, much more so than in the other periods. Regardless of whether it is due to manufacture or selectivity, the high proportions of shaped flake tools found at Type 1 sites in all phases indicates a more specialized lithic inventory at central base sites, as predicted by Chatters.

Table 10-10. Comparison of CCS tool categories by site type within phases[1].

Phase	Site Type	Sh. Flakes	Ret. Flakes	Util. Flakes	Tab. Knives	Sample Size
Coyote Creek	1	20.8	37.7	41.4	0.1	2304
	2	20.9	34.3	44.8	0.1	1801
	3	19.6	25.7	54.7	-	572
Hudnut	1	27.0	34.2	38.7	0.1	1799
	2	22.9	36.2	40.8	-	955
	3	11.8	36.8	51.3	0.1	680
Kartar	1	26.1	40.7	33.2	-	494
	2	19.5	34.9	45.6	-	195
	3	13.0	20.8	66.2	-	783

1. See Table 10-8 for frequency data.

MICROBLADE INDUSTRY

Microblade industries were identified at several project sites. Analysis of intersite distributions suggests that a microblade technology was used by the prehistoric inhabitants from at least 7000 B.P. until 3000 B.P., but that it played a restricted role in the cultural system, only being used at temporary field camps and stations/locations. Previous research on microblades in the Plateau addresses the historical significance of microblades but a new approach must be taken toward interpretation of their functional significance.

Previous Research

A number of researchers, including Borden (1950), Munsell (1968), Browman and Munsell (1969, 1972), and Sanger (1968, 1970a,b) describe microblade industries in the Pacific Northwest (including the Columbia Plateau) and discuss their significance. The questions addressed by these researchers are culture historical in nature: 1) did microblade technology diffuse to the Pacific Northwest from the North American Arctic and Subarctic regions, and if so, when, and in combination with what other traits; 2) are there distinct traditions of microblade technology within the Pacific Northwest and what are their age ranges and geographic boundaries? The underlying assumption is that the occurrence of this sophisticated and complex technology is appropriately explained in terms of historical mechanisms because it was more likely to be diffused from a single source than independently invented.

Sanger (1968) defines the Plateau Microblade Tradition as a distinctive and long-lived technique of microblade production found on the British Columbia Interior Plateau and the Columbia Plateau (data for the latter collected by Munsell 1968). It can be distinguished in terms of techniques of manufacture and morphology not only from microblade traditions in the Arctic and Subarctic of North America, but also from the microblade industry found in the coastal areas of the Pacific Northwest. Explanations that interpret the spread of microblades to the south as evidence of mass migration (eg. Borden 1950) have been rejected on the basis of subsequent research (Munsell 1968; Sanger 1968; Browman and Munsell 1969). Sanger (1970b) concludes that while the ultimate origin of the Plateau Microblade Tradition is to the north, the divergence must have taken place at least 9000 years ago, and no known archaeological assemblage represents the ancestral tradition. He argues that the microblade industry is an extremely functional cultural subsystem that is relatively coherent and resistant to modification. Microblade technology diffused to the Pacific Northwest without necessarily being attached to other cultural traits, and was adopted into indigenous cultures, even though they had established rather different kinds of lithic technology. The Plateau Microblade Tradition persisted for close to 5000 years, although microblades occur in increasingly smaller numbers through time. Microblades are more common in the British Columbia Interior Plateau than on the Columbia Plateau. The materials used for making microblades--vitreous basalt in south central British Columbia, obsidian in central British Columbia, and jasper and chalcedony on the Columbia Plateau--reflect local availability yet the microblades and cores of the Plateau Microblade Tradition show a remarkable uniformity in size and morphology throughout their temporal and geographic distributions (see Munsell 1968; Sanger 1968; Browman and Munsell 1969; and Sanger 1970b for morphological and metric traits).

According to Sanger (1968:113), "The microblade tradition has played an important role in the development of the historic Plateau culture area." The importance of the role is apparently assumed from the lengthy and widespread association of microblades with cultural assemblages, because culture historical research has not addressed the question of what the role is.

Culture historical research has established a number of important parameters: 1) a microblade industry was present in the Plateau region from nearly the time of the earliest occupation; 2) the Plateau Microblade Tradition has features distinguishing it from microblade technologies in other areas; and, 3) the microblade technology persisted for a long time even as cultures adapted to their local environments. With this framework established, the interesting questions now to be addressed concern the functional significance of a microblade technology in the local cultural adaptation.

Functional Interpretation of Microblades

If we are to consider microblade industries from a regional systemic perspective aimed at understanding the evolution of cultural adaptations, a different approach is required. The functional role played by the microblade industry in the cultural system at any given time period must be inferred from its variable association with different site types, different environmental settings, and other artifact classes, as well as evidence about use of the objects, i.e. morphological indications of wear and hafting. The following discussion focuses on inter-site distributions rather than on interpretations of function from wear and modification.

We should not assume that the frequency of microblades is necessarily the same at all kinds of sites at a given time period, but that microblades may be associated, for functional reasons, with particular site types. Interpretations made by Sanger (1970b) about frequency of microblades through time in the Lochnore-Nesikep locale are suspect because the representativeness of the sample and the possibility of regional variability is not considered. He treats the differences in frequency between sites dated around 7000 B.P., where microblades occur only in minor percentages, and at the Lehman site with a single date of 6600 B.P. where microblades account for nearly 50% of the artifacts as having temporal significance. Given the findings of this project, that microblades have a restricted occurrence--they are associated with particular kinds of sites and absent from other sites of similar age--it seems more likely that the sites dated around 7000 B.P. and the Lehman site are parts of similar cultural systems and that the difference in microblade frequency is due primarily to functional differences between the sites.

Because not all products of a microblade industry can be deterministically separated from those of other flaking processes, the goal is not necessarily to conclusively determine the presence or absence of a microblade industry in every component, but to systematically tabulate the occurrence of artifact classes or attributes thought to be related to microblade production.

The question of appropriate criteria for recognizing microblade industries has received considerable discussion in connection with culture historical research. There is general agreement that the occurrence of cores of appropriate morphology is a reliable criterion for the presence of a microblade industry (Sanger 1968:95, 1970b:106; Browman and Munsell 1972). Cores bear the scars of a number of separate events and are unlikely to be produced fortuitously. However, the criterion of cores is too restrictive, especially when blade to core ratios of 33:1 are common (Sanger 1968). Therefore, it is frequently desirable to make a determination on the basis of the linear flakes themselves, a more complex issue. It is generally accepted that it is not possible to completely separate all linear flakes of appropriate size into microblades and non-microblades, because of the potential overlap in morphological characteristics between flakes struck from a prepared microblade core and others produced by general flake production or retouching. Evidence of core preparation on the proximal end of the linear flake is a relatively good indicator, but Sanger also calls for evidence of successive flake removal (1968, 1970b). In this case, recognition of a microblade industry depends on characteristics of the assemblage, not of individual objects. Sanger suggests the criterion that in an assemblage of small parallel-sided flakes more than 25% of the specimens have a trapezoidal cross section (1968:95, 1970b:106). Browman and Munsell (1972) take exception to this criterion because of empirically demonstrated variability in the proportions of flakes with multiple arrises in Columbia Plateau assemblages. Likewise, they reject criteria based on the overall proportions of microblade products in the lithic assemblage because this also has been found to be variable across the Columbia Plateau. Ultimately, as Browman and Munsell (1972) point out, there is no satisfactory criteria for determining if a microblade industry is represented when a very small number of small, parallel-sided flakes, and no cores, are present.

In the culture historical approach, recognizing microblade industries from only a small number of linear flakes has proven to be a problem primarily when the boundaries of the temporal and geographic distributions of microblade traditions are in question. For example, Sanger (1968, 1970b) and Munsell and Browman (1969, 1972) debated the validity of recognizing a microbade industry at the Drynoch Slide site on the basis of a single microblade only because it came from a context dated to approximately 7500 B.P., older than any other evidence of microblades in the Pacific Northwest. Otherwise, the culture historical questions do not require making a determination about every questionable assemblage; the historical parameters--morphology, age, and areal extent--of microblade traditions can be established on the basis of sites such as the Ryegrass Coulee site (Munsell 1968) or the Lehman site (Sanger 1970a) at which microblade industries are unequivocally represented.

In a regional systemic approach, the issue of how to deal with small assemblages is more critical because of the need to collect systematic distributional data. Two approaches can be taken. One is a deterministic approach, to systematically record only those objects that are definitive products of microblade production (those that could not be produced by other industries). The other is a probabilistic approach, to record the occurrence of traits and objects possibly related to microblade production and evaluate the data in terms of population (assemblage) characteristics. There are advantages to each, and a combination of the two would be most effective.

The first approach should incorporate development of more refined morphological criteria for local microblade industries. Given differences in materials and core preparation techniques that have been demonstrated among regions, criteria should be local and not based on morphology from other areas. This could be done by a combination of replicative experiments and detailed studies of established local microblade industries. Greater care would need to be taken in identifying definitive products, for example, looking more carefully for core fragments as well as complete cores. Counts of definitive microblade products can then be used in looking at regional distributions of microblade industries. The main drawback of this approach is that the numbers of definitive products always would be small, and therefore, small sample sizes and sampling bias would pose problems in making regional interpretations. For example, because the Plateau Microblade Tradition is characterized by use of a weathered surface rather than a fresh surface for a striking platform, and because core rejuvenation tablets are not known, there may be few distinctive products of microblade production other than microblades and cores.

An example of this first approach is a study by Kelly (1982) who analyzed a microblade industry from three sites (45-LE-88,45-LE-123, and 45-LE-130) in southeastern Washington. The archaeological materials, largely from surface collections, are dated only by associated Cascade bipoints (8000-2000 B.P.) and stemmed point varieties dated between 6000 and 2000 B.P. The exhausted cores are blocky with a rough cylindrical or conical shape and range in size from 1.5 to 3.0 cm. They have circular or ovoid platforms. Blade detachment is almost consistently unidirectional and the arc of blade detachment varies from one-third to two-thirds the perimeter of the core. The microblades are more concave than straight in cross-section, more triangular than rectangular in overall shape, and have from 2 to 5 dorsal arrises. Lateral width varies from 0.2 to 0.7 cm.

Using replicative techniques (Flenniken 1979) Kelly was able to closely duplicate the archaeological sample of microblades and exhausted cores. Prehistoric raw materials were matched by selecting chert and chalcedony pebbles and cobbles from nearby river deposits. Two methods of primary reduction appear to have been used, one involving bipolar reduction of heat treated pebbles, the other free-hand reduction of cobble and subsequent heat treatment. The byproducts of the first technique--pie-shaped wedges and miscellaneous shatter--are indistinguishable from any other bipolar core reduction. The byproducts of the second technique include large flakes usable for making bifaces. After the initial reduction, the remaining nodule was modified into a microcore by first modifying the shape of the wedge or nodule, then preparing the platform, and finally by forming the fluted surface. The byproducts of these stages are indistinguishable from the debitage of other reduction sequences. The microblades were also compared with lamellar flakes from biface manufacture, made by replicating three of the projectile points associated with the cores and microblades. It was virtually impossible to distinguish the two. In other words the manufacturing sequence that most closely duplicated the blades produced many products nondistinctive from biface manufacture.

This work is a demonstration that even using sophisticated lithic technological studies it will not be possible to deterministically identify every single item as a product of a microblade industry or not. Some products of microblade production will always overlap with some products of other lithic manufacturing activities. Both kinds of error in identification could occur. Some microblade debitage will be indistinguishable from debitage of other processes, and some products of other manufacture will be indistinguishable from microblade products. Also, we should not assume that microblade production was necessarily separate from other lithic manufacturing activities in practice. Not only did they take place at the same locations, but there may have been exchange between the systems. As Lohse (1984d:40) comments, cores or chunks that are products of the one process can be readily adapted for use in the other.

The alternative approach is to count classes and traits of objects that are associated with microblade production, but not necessarily exclusively. This approach is simpler because it involves fewer assumptions. Because it is not possible to deterministically identify microblades so that all microblades and nothing but microblades are included, the emphasis should be not on identifying individual microblades but on counting morphological classes of linear flakes and making the argument about the likelihood of microblade production being practiced from the overall proportions. For example, we could look at the proportions of linear flakes with multiple arrises through time. If an increasing number of the linear flakes are pressure flakes through time, rather than microblades, we would expect to see the proportion of multiple arrises decrease.

The issue of whether to approach microblade technology by deterministic application of a stage model of microblade manufacture or to approach it by measuring traits at the population level is an example of a more general issue recently raised about the strategy of lithic technology studies. Sullivan and Rozen (1985) and Teltser (n.d.) both argue that stage models cannot be deterministically applied and that the appropriate scale of analysis is the population. I suggest that stage models still have an extremely important role to play; they supply a framework within which certain traits have significance and population characteristics can be interpreted. Also, some deterministic identifications should be made to provide some limits to the kinds of technological activities that contributed to an assemblage (eg., identifying bipolar core, microblade cores, and other cores). Otherwise there are too many unknowns in interpreting shifts in the frequency of object types or traits. However, it clearly is productive to shift from attempting to identify individual artifacts with particular stages or technological events to looking at the population characteristics.

Project Data Collection

In order to identify possible microblades, the project established the category **small linear flake,** defined as parallel-sided flakes <1 cm in width and twice as long as they are wide. The term **linear flake** is suggested by

Sanger (1970) for parallel-sided blade-like flakes that have not been established as the products of prepared blade core industries. The 10 mm cutoff for size is used by Browman and Munsell (1969). Small linear flakes were found at all excavated sites, in nearly every analytic zone. Each descriptive site report evaluates the small linear flakes from that particular site in terms of whether they constitute evidence of a microblade technology. The evaluations were generally made on a site-by-site basis rather than a zone-by-zone basis.

All small linear flakes were examined for wear and secondary manufacture in the standard functional analysis. Wear was found on very few.

At the following sites, the authors conclude that a microblade industry was present: 45-DO-273 (Jaehnig 1984a), 45-DO-282 (Lohse 1984d), 45-DO-326 (Lohse 1984e), and 45-OK-18 (Jaehnig 1984b). In each of these cases, cores are present, the small linear flakes occur in relatively high proportions, and the morphological features of the flakes match those published by Sanger (1968) and Munsell (1968). Lohse (1984a) also concludes that the seven small linear flakes at 45-DO-204 were probably microblades as the blade dimensions and cross sections match published descriptions and those at 45-DO-282.

A number of other project sites have low frequencies of small linear flakes and lack microblade cores, and thus no good evidence of a microblade industry: 45-DO-214 (Miss 1984a), 45-DO-242 (Lohse 1984c), 45-DO-243 (Lohse 1984c), 45-DO-285 (Miss 1984b), 45-OK-2 (Campbell 1984b), 45-OK-2A (Campbell 1984), 45-OK-4 (Miss 1984c), 45-OK-11 (Lohse 1984f), 45-OK-250 (Miss 1984c), 45-OK-258 (Jaehnig 1983) and 45-OK-287/288 (Miss 1984d). Miss provides general descriptions of the morphology of small linear flakes from sites 45-DO-214, 45-DO-285, 45-OK-4, 45-OK-250, and 45-OK-287/288. While they are blade-like in terms of length-to-width relationship, they lack the multiple arrises, trapezoidal cross section, and near-right angle platform characteristic of microblades (Sanger 1968). In most cases there is a single dorsal ridge, a triangular cross section and an acute platform angle < 60 degrees. She concludes that the small linear flakes are pressure flakes.

The problem with the site-by-site evaluations of the linear flakes is that they did not result in the systematic tabulations we would ideally like to have of data on size, breakage, and morphology of linear flakes from all zones at all sites. In those cases where there was clear evidence of a microblade industry based on the presence of cores (and also at 45-DO-204), metric data and systematic information on morphology were collected. However, this was not necessarily done by zone, but for the entire site assemblage. In those cases where authors decided that microblades were not present, measurements and attributes of the small linear flakes are not provided. This is unfortunate. As recommended above, because of the overlap between microblades and retouch flakes systematic tabulations of bladelet characteristics should be made even for assemblages not thought to have microblade industries.

Our only systematic data is thus at a general level--the frequency of small linear flakes and microblade cores by material category without additional morphological data. Looking at this data by phase and site type

(Table 10-11) we see that small linear flakes constitute small proportions of lithic assemblages except in Kartar Phase Type 2 and 3 sites. However, we also see that cores have been found in assemblages assigned to all three phases. On the basis of this evidence we cannot rule out microblade production in all three phases. The small linear flakes are overwhelmingly of CCS materials, although the greatest diversity in materials is found in the Kartar Phase. This may simply reflect the larger sample size for the Kartar Phase, but it is also consistent with the material proportions in general lithic manufacture, which is not as heavily dominated by CCS materials as later phases. It is surprising, however, that non-CCS cores occur in Hudnut and Coyote Creek Phase contexts, but not in Kartar Phase contexts.

Following is a phase by phase discussion which takes into account both the systematic data on linear flake frequencies shown in Table 10-11 as well as the more detailed descriptions of microblade assemblages from individual site reports.

Kartar Phase

The industry is best represented at 45-DO-282 (Lohse 1984d), where 173 microblades and 13 cores were recovered from five zones, all of which are assigned to the Kartar Phase and Site Type 3. The dimensions of both the microblade cores and microblades in this collection are very similar to those recorded by Sanger (1968) and Munsell (1968) for microblades elsewhere on the Columbia Plateau and British Columbia Interior Plateau. The sizes and platform edge angles of the cores are very uniform, as are the blades. The width of the blades is less variable than the length. Most of the blades are snapped distally and/or proximally, and many of the blade scars on the cores end in abrupt hinged fractures, suggesting most of the breaks occurred in detachment. Only six of the microblades had macroscopically visible wear, consisting of feathered chipping on unifacial or bifacial edges. Production of microblades apparently was associated with 45-DO-282 from its earliest occupation around 7000 B.P. until 4000 B.P.

A microblade industry is clearly present in the two Kartar Phase zones at 45-DO-273, dated to 5500 and 4500 B.P. and both assigned to Site Type 3. Jaehnig (1984a:87-88) discusses the assemblage--two microblade cores, one core fragment, and 104 small, linear flakes--as a whole. The microblades compare well with metric attributes published by Sanger (1968) although those from 45-DO-273 are generally shorter. The microblade core measurements are similar to those published by Sanger (1968) and those from Ryegrass Coulee (Munsell 1968) although the striking platforms on the 45-DO-273 cores are somewhat longer than the Ryegrass Coulee examples. The bulk of the linear flakes (62) and two of the cores come from the three oldest zones, all of which are assigned to the Kartar Phase and Site Type 3; however, small linear flakes were also recovered from the upper two zones, both assigned to Type 3 and the Coyote Creek Phase.

Small linear flakes thought to be microblades also are found in Kartar Phase Type 3 zones at 45-DO-204. At other sites, zones assigned to Site Type

Table 10-11. Frequency of small linear flakes and microblade cores by phase and site type.

Phase	Site Type	Small Linear Flakes							Total Lithics	% Small Linear Flakes	# of Cores (CCS)	# of Core Fragments		
		CCS	Obsidian	Basalt	Qtzite	Argillite	Other	Total				CCS	Qtzite	Basalt
Coyote Creek	1	155	–	–	–	–	–	155	61206	0.003	–	–	–	–
	2	63	–	–	–	–	–	63	33834	0.002	–	–	–	–
	3	81	–	–	–	–	–	81	19586	0.004	1	–	–	1
Hudnut	1	62	–	–	–	–	–	62	58436	0.001	–	–	–	–
	2	145	–	4	1	–	–	150	34955	0.004	1	2	1	–
	3	59	–	3	1	2	2	67	31244	0.002	–	–	–	–
Karter	1	2	–	1	–	–	–	3	27027	<0.001	–	–	–	–
	2	93	1	3	–	4	–	101	4937	0.020	–	–	–	–
	3	170	–	2	–	–	1	173	8178	0.021	15	1	–	–

3 and the Kartar Phase have at least one small linear flake (45-DO-243, Zone 4; 45-OK-2A, Zone 3). However, small linear flakes are absent in Zone 4 at 45-DO-242, with a total lithic assemblage of 75 objects, and Zone 4 at 45-OK-2A, with a total lithic assemblage of 59 objects. The absence of small linear flakes in these zones could be due to the small sample size, although these are not the smallest assemblages; Zone 4 at 45-OK-18 has four microblades among its 55 lithic objects, and Zone 5 at 45-DO-273 has 2 microblades among 57 objects. However, Zone 53 at 45-OK-4, a mixed Kartar/Hudnut zone, has no linear flakes among 994 lithic objects.

Site Type 2 is represented by Zones 5 and 6 at 45-OK-288, dated from before 4800 B.P. to 4400 B.P. The proportions of small linear flakes are quite high (Zone 5=2.4% and Zone 6=1.4%); in fact, they are as high or higher than the proportions in the 45-DO-282 zones (0.6% to 2.3%). However, Miss (1984d) holds the opinion that the flakes do not display the morphology expected of microblades. Because the only other sites which have such high proportions of small linear flakes do contain evidence of microblade production in the form of cores, it would be appropriate to re-examine the small linear flakes from 45-OK-287/288 and compare tabulated measurements and morphological traits with those from established microblade industries.

Although comparable in age, the single Kartar Phase residential (Type 1) site, occupied between 5100 and 4200 B.P., presents a remarkable contrast in terms of the occurrence of microblades. The assemblage of 27,027 lithics included only 3 small linear flakes. Lohse notes that the morphology of the few small linear flakes found in both the Hudnut and Kartar components at 45-OK-11 is similar to those found in association with microblade cores at other sites (Lohse 1984f:73). Based on the low frequency and the lack of cores he concludes that a microblade industry was not present at the site, since such blades could be produced fortuitously by the more common flake tool industry.

Hudnut Phase

The overall proportions of small linear flakes are lower in the Hudnut Phase than in the Kartar Phase. However, sites 45-OK-18 and 45-DO-326 provide evidence for microblade production during at least the first half of the Hudnut period, from 4000 until 3000 B.P.

Small linear flakes are quite rare at Hudnut Type 1 sites; of the seven zones included, none had proportions higher than 0.2%. Proportions at four of the Type 2 zones ranged from 0.5% to <0.1%, in contrast to 45-OK-18, zone 2 (1.8%) and 45-DO-326 (3.0%). Percentages at Type 3 sites ranged from 0.1 to 0.4%.

The assemblage from 45-OK-18 (Jaehnig 1984b) includes 103 small linear flakes and two objects that probably are fragments of microblade cores. Of the small linear flakes, 90 fit the dimensions of microblades. Of these, 57 (63%), have trapezoidal cross sections and the remainder have a single arris. Although small linear flakes are found in all four zones at the site, the two cores and the majority of the flakes are found in Zones 2 and 3, which are Hudnut Type 2 and Type 3 sites respectively. The three Hudnut Phase occupations at 45-OK-18 fall within the time span 4000 to 3000 B.P. Four microblades may or may not be in situ in the oldest zone, Zone 4, assigned to the Kartar Phase.

The 45-DO-326 assemblage includes 169 microblades and 4 cores (Lohse 1984e). The measurements and morphological attributes of the blades and cores are very similar to those published by Sanger (1968) and Munsell (1968). However, one of the cores shows multiple striking platforms, documenting routine core rotation. Such cores are scarce in the Plateau Microblade Tradition, which is generally characterized by cores with use restricted to a carefully prepared frontal edge (Sanger 1968, 1970b). A total of 75 of the microblades and two of the cores are in Zone 3, a Hudnut Phase occupation dated between 4000 and 3000 B.P.; 50 microblades and one core are from Zone 4, a Kartar Phase occupation dated between 5000 and 4000 B.P.

Coyote Creek Phase

In 15 of the 22 Coyote Creek Phase zones the proportion of small linear flakes in the lithic assemblage is between 0.3% and <0.1%. The other seven cases (Zones 1, 2, and 3 at 45-OK-288; Zones 1 and 2 at 45-DO-273; and Zones 1 and 2 at 45-DO-326) have proportions ranging from 0.6 to 3.7. The two examples of cores in Coyote Creek Phase sites are from 45-DO-273, Zone 2, and 45-DO-326, Zone 2. Each of these sites has been previously discussed as having a microblade technology, the bulk of the evidence for which is in Kartar or Hudnut-aged assemblages. I suggest that the high frequencies of small linear flakes and the presence of cores in these Coyote Creek zones is due primarily to mixing. However, the possibility that microblade production took place at these sites throughout the occupation span of the area because of proximity to appropriate lithic sources or some other functional reason cannot be ruled out. At any rate, the overall frequency of small linear flakes is so low in the Coyote Creek Phase that if microblades were still being made, their production had declined to a relatively minor activity.

DISCUSSION

Let us return to the initial expectations and evaluate them. On the whole, the evidence does indicate the greatest specialization in technology at Type 1 sites and the least at Type 3 sites, as predicted, although different categories of data provide slightly different perspectives. On the other hand, we found little evidence of specialization through time.

We expected to see, within a given time period, the greatest selectivity in raw materials and the greatest investment in manufacturing specialized tools at Type 1 sites, and the least at Type 3 sites. In terms of selectivity of raw materials, we expected that the proportions of raw materials at Type 3 sites would most nearly reflect their availability in the immediate vicinity, and at Type 1 sites the least. Therefore, we were surprised that the highest quantities of CCS, uncommon in the river gravels, occurred at Type 3 sites and that the highest quantities of quartzite, more common in the river gravels, occurred at Type 1 sites. However, when we looked only at flake tools, rather than all lithics, thus omitting unutilized debitage, we did find the greatest proportions of CCS at Type 1 sites and the least at Type 3 sites. It appears that the relatively inefficient tabular quartzite industry, which produces a much higher ratio of used to discarded flakes affects the overall proportions. In terms of evidence of greater investment in manufactured tools at Type 1 sites, we did find the expected pattern when we looked at the distribution of CCS products by site type. The highest proportions of shaped tools were at Type 1 sites and the lowest at Type 3 sites, while the proportions of utilized-only flakes were reversed.

The role of the bipolar flaking of tabular quartzite cobbles and the production of tabular quartzite knives needs to be clarified. This industry has the earmarks of a very specialized technology that takes advantage of the uniform physical qualities of a unique and locally abundant resource, quartzite cobbles. Also the distribution of categories based on degree of modification should be examined for material types other than CCS, and for cobble tools, to see if the same pattern holds. A more convincing argument about the nature of lithic manufacturing activities by site type can be developed using other technological data such as frequency of primary flaking products, size of flakes, and breakage data.

For each field of data considered above, marked differences were found among the site types in terms of the proportions of lithic products occurring there. This is strong evidence of patterned scheduling of lithic manufacturing activities, probably associated with the lithic tool requirements of the subsistence activities being practiced at the site, and perhaps also influenced by the lithic sources encountered in the catchment areas being exploited. In other words, lithic manufacturing activities vary regularly with the seasons and activities undertaken, rather than being randomly or uniformly distributed. That the patterns of inter-site variation were generally the same throughout all three phases is remarkable, given the shifts in material distribution through time.

The association of microblades with locations/stations (Type 3 sites) and possibly field camps (Type 2 sites) in the Kartar Phase and with some Type 2 and 3 sites in the Hudnut Phase is one of the most interesting findings of this study. Microblades are not associated, in any phase, with Type 1 sites, longer term settlements where raw materials could be accumulated and tools stored and more time devoted to manufacturing. Microblade industries commonly have been treated as specialized, sophisticated, complex systems of lithic manufacture. This might be thought to indicate that activities at sites where microblades are found were relatively specialized, requiring special types of lithic reduction. However, the faunal remains and lack of features at Kartar Phase Type 3 sites reflect generalized, opportunistic foraging, not specialized activities (see Chapter 15). The Type 2 occupations are less generalized, but still relatively temporary, and the Hudnut Phase occupations with microblades also appear to be short term camps. I suggest that the reason microblades are associated with transitory camps where opportunistic foraging was practiced is that microblade production is one of the most efficient and portable means of providing expedient, generalized tools. Microblade cores are light and not costly to transport and the blades can be taken off quickly as needed. The major problem with this interpretation is the scarcity of wear noted on the microblades. Further research might be directed toward collecting evidence to indicate whether the microblades were used in making composite tools, and whether assemblages at sites like 45-DO-282 include utilized microblades or only discarded debitage.

At any rate, the production of microblades at stations/locations may account for the disproportionate amounts of CCS previously noted at Kartar Phase Type 3 sites. It is unlikely that the special activity connected with Type 3 sites is microblade production itself; if that were the case, then one would expect to see microblades present at the residential (Type 1) sites. It appears that microblades were being manufactured only for use in areas other than residential sites.

We cannot claim to have evidence of an increasingly specialized lithic technology through time. In the data most clearly relevant to measuring specialization of technology, i.e., the proportions of shaped, retouched, and utilized-only tools, we did find that the oldest phase had the lowest proportions of shaped tools, but there was not a linear trend through time, as the highest proportions occurred in the Hudnut Phase. Changes in lithic material proportions through time are quite apparent, but are difficult to relate to the question of changes in specialization through time. Within a given time period, it is reasonable to contrast the proportions of materials at different site types and relate these to selectivity in use. Through time, however, this is difficult. We do not know to what extent the cultural use of lithics altered the availability of materials through time, or to what extent trade networks changed, or territories changed in size, affecting the contact with lithic sources, nor have we controlled for changes in the use of the material types. Therefore, we do not know the meaning of a gradual decrease in the amounts of basalt and quartzite and increase in the amount of CCS used for manufacturing flake tools. Evidence of conservatism in the scheduling of lithic manufacturing activities and association with other activities was mentioned above; the patterns of inter-site variation are quite similar from phase to phase with the exception of the high proportions of CCS at Type 3 sites in the Kartar and the association of these sites with microblades.

SHELL ARTIFACTS

All shell artifacts from project sites are ornaments, either beads or pendants. These include Dentalium or Olivella shells minimally altered to facilitate stringing as well as flat disks cut from shell with a hole in the middle. The shell disk beads have not been identified to species and may be local freshwater shells. Dentalium and Olivella, on the other hand, are imported marine shells. Marine shells provide our most useful means of establishing that prehistoric cultures in the area participated in trading networks extending to the coast. Table 10-12 shows the frequency of shell ornament types by phase. Clearly trade networks were in effect for the known occupation span in the project area. Differences in frequency are suggestive, but numbers are so small that the apparent trend indicating replacement of Olivella by Dentalium through time may not be valid.

Table 10-12. Shell ornaments by phase

Phase	Site	Zone	Site Type	Dentalium	Olivella	Disc	Pendant	Total
Coyote Creek	45-DO-214	3	2	1	-	-	-	1
	45-DO-326	1	2	1	-	-	-	1
	45-OK-2	1	1	2	-	-	-	2
		2	1	-	-	1	-	1
	45-OK-250	51^1	2	2	-	2	-	4
	Total N %			6 66.7	-	3 33.3	-	9
Hudnut	45-OK-2	3	1	-	-	5	-	5
		4	2	-	1	2	-	3
	45-OK-4	52	1	4	-	1	-	5
	45-OK-250	52	1	3	3	4	-	10
	45-OK-258	4	1	-	1	-	-	1
		5	1	1	2	4	1	8
	Total N %			8 25.0	7 21.9	16 50.0	1 3.0	32
Kartar	45-OK-11	B	1	-	1	2	-	3
	45-OK-250	53^2	2	-	-	2	-	2
	Total N %			-	1 20.0	4 80.0	-	5

1. Mixed Coyote Creek and Hudnut phases.
2. Mixed Kartar and Hudnut phases.

FISHING TECHNOLOGY

Archaeologists on the Plateau have long been plagued with difficulties in measuring the importance of fishing among prehistoric peoples. Even in sites from the ethnographic period, fish remains are seldom as common as might be expected among people who intensively fished for some part of the year. Equipment presumed to be connected with fishing--netweights, points, gorges, and barbs--is important supplementary evidence for identifying fishing sites. Such equipment recovered from a number of project sites is described below.

In the project area there is no netweight complex similar to that on the Snake River and lower on the Columbia River. The five netweights recorded at the project come from Kartar, Hudnut, and Coyote Creek contexts (Table 10-13); thus there is no qualitative difference among the phases. None of the examples have been more than minimally modified with a notch on one or two sides. It seems likely that the inhabitants' primary means of weighting nets or other fishing implements and constructions was by lashing unmodified rock in twine.

Table 10-13. Occurrence of specialized fishing equipment by site and phase.

Phase	Site	Zone	Net Weights	Composite Harpoon Points	Composite Harpoon Valves	Large Barbed Unipoints	Round X-section Unipoints	Slender X-section Bipoints
Coyote Creek	45-DO-214	2	–	2	–	–	–	–
		3	–	6[1]	3	–	–	3
	45-DO-244	Burial 2	–	2	4	–	–	–
	45-OK-2	1	1	1	2	–	–	–
		2	–	–	–	–	1	–
	45-OK-258	2	–	1	–	–	–	1
Hudnut	45-DO-273	3	1	–	–	–	1	–
	45-OK-2	3	–	–	–	–	1	–
	45-OK-4	52	–	–	–	–	–	2[2]
	45-OK-11	A	1	–	–	3	–	–
	45-OK-250	52	–	–	–	1	–	–
	45-OK-258	4	–	1	1	–	–	–
Kartar	45-OK-11	B	2	7	1	1	3	8
	45-OK-250[3]	53	–	–	–	1	–	–

1. One of these is a self-valved point.
2. See Plate 3-7g and Figure 3-17f.
3. Mixed Hudnut and Kartar Phase.

A variety of bone points and barbs found in Plateau archaeological assemblages are interpreted as specialized fishing equipment. These include barbed points with holes for attaching a line, composite harpoon points where the barbs are attached separately, less specialized rounded points, and slender points that could have functioned as gorges or in composite fishing tools such as leisters or hooks. A total of six large, barbed harpoon points were found in project assemblages, all in Hudnut or Kartar Phase components (Table 10-13). Composite harpoon assemblies are represented by both points (unipoints with a round cross-section at the distal end, tapering to a wedge-shaped proximal end) and valves in assemblages from all three periods. Two sets of valves and points were found in a burial at 45-DO-244, dated around 160 B.P. (Campbell 1984). The 45-DO-214 Coyote Creek Phase assemblage includes two types of composite harpoon assemblies; a self-barbed point used with one other valve and the more common kind made to be used with two valves. It would be useful to compare the morphology of the points and valves in the three phases to determine if there are stylistic, functional, or technological changes. Round unipoints without tapered proximal ends, possibly part of a different type of harpoon assembly, and slender round bipoints that could have functioned as leister barbs or gorges have been found in assemblages of all three phases.

These artifact types are such rare components of site assemblages that inter-site and inter-period comparisons are subject to serious sampling biases. In terms of temporal trends, we can only conclude that specialized fishing equipment was used for the entire span of occupation, and that diversity in fishing equipment may actually have decreased through time, as large barbed harpoon points have not been found in contexts dating after 2000 B.P. However, the two types of composite harpoon points at 45-DO-214 may indicate a diversification along new lines. Unfortunately, we cannot draw conclusions about site function from this information. The two sites containing the greatest numbers of fish bones, 45-DO-211 and 45-DO-285, have no recognized fishing equipment. Apart from 45-DO-214, the only sites with fishing equipment are residential sites that were used longer and with more intensity than any other sites in the project area. They may have been fishing bases during part of the year.

The numbers of bone harpoon points and barbs are underestimated somewhat by this tabulation because generally only relatively complete objects were classified as barbed harpoon points or composite harpoon points and valves. Fragments of bone tools were assigned to categories such as "shaft fragment", "pointed bone fragment", or "indeterminate". The proportion of modified bone objects placed in these fragment categories is so large that an analysis focusing on assigning fragments to tool categories would greatly increase the sample size. For example, at 45-OK-258, while only two unipoints, one bipoint, and eight awls were recorded, a total of 34 objects were placed in the category pointed bone fragments. A detailed analysis of modified bone that systematically recorded information on cross-section, symmetry, and size ranges of dimensions such as shaft thickness for whole tools would allow more fragments to be assigned to tool types. This might sufficiently augment sample sizes so that fishing equipment could be used quantitatively in defining site function.

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11. RUFUS WOODS LAKE PROJECTILE POINT CHRONOLOGY

Testing and salvage operations from 1977 to 1980 within the Rufus Woods Lake Reservoir on the upper Columbia River produced a large collection of projectile points spanning the last 6-7,000 years. Over 1,500 complete and fragmented specimens were recovered from 18 excavated and 61 tested archaeological sites. Excavation exposed over 60 separate cultural components indexed by 161 radiocarbon dates. This detailed cultural record provided us with a unique opportunity to construct a sequence of projectile point types that can be used as a reference for comparing the cultural record of the Rufus Woods Lake area with others defined for the northern Columbia Plateau.

Work over the last thirty years has identified several projectile point types with demonstrable historical sensitivity (e.g., Nelson 1969; Rice 1969, 1972; Leonhardy and Rice 1970). However, these types have in many cases not been rigorously defined, nor have similar forms with comparable temporal ranges been grouped within type series. As a result, there is no clear, explicit formulation of a projectile point type sequence with standardized terminology and typological format. There is thus no basis for rigorously comparing projectile point forms recovered in one project area with those already analyzed and described in another. The challenge is to construct a classification scheme that is consistent and easily applied across the broad area of the Columbia Plateau.

To this end, and as a necessary prerequisite for comparison of the Rufus Woods Lake projectile point collection to that of the Columbia Plateau as a whole, we have attempted to formulate a classificatory system that incorporates past work, has the facility to consistently and easily compare a range of projectile point forms over a broad area, and that is statistically as well as qualitatively derived.

HISTORICAL ANALYSIS

Development of the project's projectile point analysis is briefly discussed in the survey report (Jermann 1985) and in the research design (Campbell 1984). Jermann (1985) describes the initial approach, numerical taxonomy using cluster analysis. This approach was discontinued when it did not yield satisfactory historical classes. However, the technique of collecting metric data by digitizing projectile point outlines developed for this first analysis was continued and greatly facilitated all subsequent analyses. Next, a paradigmatic morphological classification was applied. While this was found to be temporally sensitive, it was difficult to relate to previously defined types in other areas. In the final stage of analysis, discriminant analysis was used to develop quantitative definitions for previously defined historical types and to assign Rufus Woods Lake projectile points to historical types.

MORPHOLOGICAL CLASSIFICATION

As a first step, all projectile points and projectile point fragments recovered from the Rufus Woods Lake project were coded within a paradigmatic classification that emphasizes the complete physical description of each specimen. Basic morphological attributes were coded within 11 classificatory dimensions: BLADE-STEM JUNCTURE, OUTLINE, STEM-EDGE ORIENTATION, SIZE, BASAL EDGE SHAPE, BLADE EDGE SHAPE, CROSS SECTION, SERRATION, EDGE GRINDING, BASAL EDGE THINNING, and FLAKE SCAR PATTERN (Table 11-1). We use the first four of these dimensions to define 18 morphological types (Figure 11-1) that approximate those projectile point types recognized for the Columbia Plateau. The other seven dimensions serve to describe the morphological types more fully, and permit the identification of variants within the types. Also, the dimensions are used to create a file of basic descriptive information that is combined with a file of metric data.

Development of the definitions and their application to actual projectile points was aided by conceiving of the point margins as series of straight lines drawn from nodes that signal changes of direction along the outlines of the specimens. This approach is illustrated by the figures on the left side of Figure 11-2. The blade is defined as line segment a-A, the shoulder is line segment A-1, and the neck is node 1. The stem is line segment 1-2-3 and the base is line segment 2-a' or 3-a'. Of course, terms applied and the number of line segments drawn vary given the basic subdivisions of form. Shouldered lanceolates are defined by three or fewer line segments (aA1a'). Stemmed lanceolate or triangular forms are defined by four or fewer line segments (aA12a'). Side-notched triangular forms are defined by five or more line segments (aA123a'). A basal notch is defined by line segment (45). (Note: insufficient landmarks were recorded on the base to allow recognition of a basal notch in the digitized outlines).

This paradigmatic classification supplied a basic description of formal variation in the projectile point collection and its temporal distribution (Figure 11-3). However, while the qualitative dimensions chosen to define morphological types were intended to aproximate recognized variation in projectile point form, they did not supply the necessary basis for direct correlation with recognized historical types. We sought a classification procedure based in a statistical measure of formal correspondence with defined historical types. To do this, we chose discriminant analysis, a multivariate statistical technique that has demonstrated utility in the classification of a large number of variables representing a complex range of form. It has been applied with varying degrees of success by a number of archaeological typologists in the classification of projectile points (e.g., Gunn and Prewitt 1975; Holmer 1978; Thomas 1981).

Table 11-1. Morphological projectile point classification.

DIMENSION I: BLADE-STEM JUNCTURE

N. Not separate
1. Side-notched
2. Shouldered
3. Squared
4. Barbed
9. Indeterminate

DIMENSION II: OUTLINE

N. Not applicable
1. Triangular
2. Lanceolate
9. Indeterminate

DIMENSION III: STEM EDGE ORIENTATION

N. Not applicable
1. Straight
2. Contracting
3. Expanding
9. Indeterminate

DIMENSION IV: SIZE

N. Not applicable
1. Large
2. Small

DIMENSION V: BASAL EDGE SHAPE

N. Not applicable
1. Straight
2. Convex
3. Concave
4. Point
5. 1 or 2 and notched
9. Indeterminate

DIMENSION VI: BLADE EDGE SHAPE

N. Not applicable
1. Straight
2. Excurvate
3. Incurvate
4. Reworked
9. Indeterminate

DIMENSION VII: CROSS SECTION

N. Not applicable
1. Planoconvex
2. Biconvex
3. Diamond
4. Trapezoidal
9. Indeterminate

DIMENSION VIII: SERRATION

N. Not applicable
1. Not serrated
2. Serrated
9. Indeterminate

DIMENSION IX: EDGE GRINDING

N. Not applicable
1. Not ground
2. Blade edge
3. Stem edge
9. Indeterminate

DIMENSION X: BASAL EDGE THINNING

N. Not applicable
1. Not thinned
2. Short flake scars
3. Long flake scars
9. Indeterminate

DIMENSION XI: FLAKE SCAR PATTERN

N. Not applicable
1. Variable
2. Uniform
3. Mixed
4. Collateral
5. Transverse
6. Other
9. Indeterminate

See Appendix J for definition of dimensions and modes.

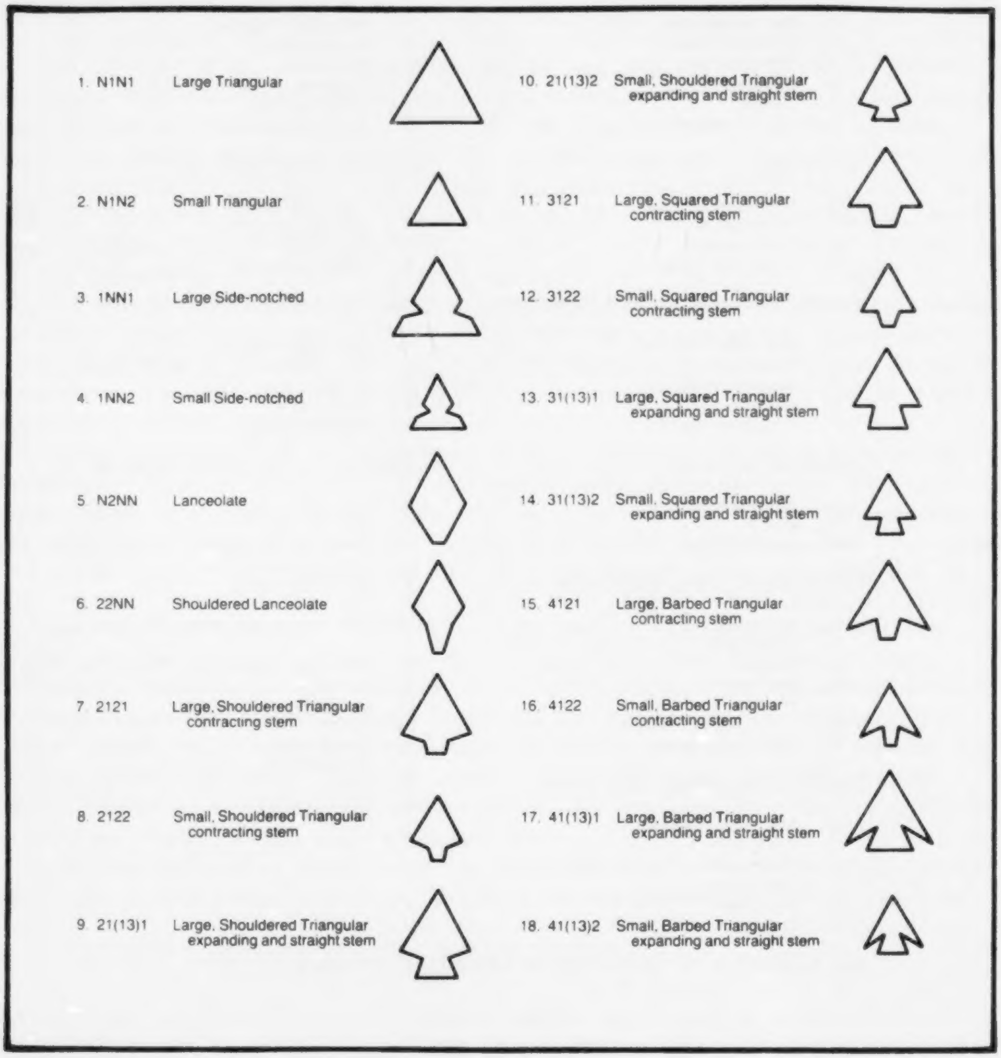
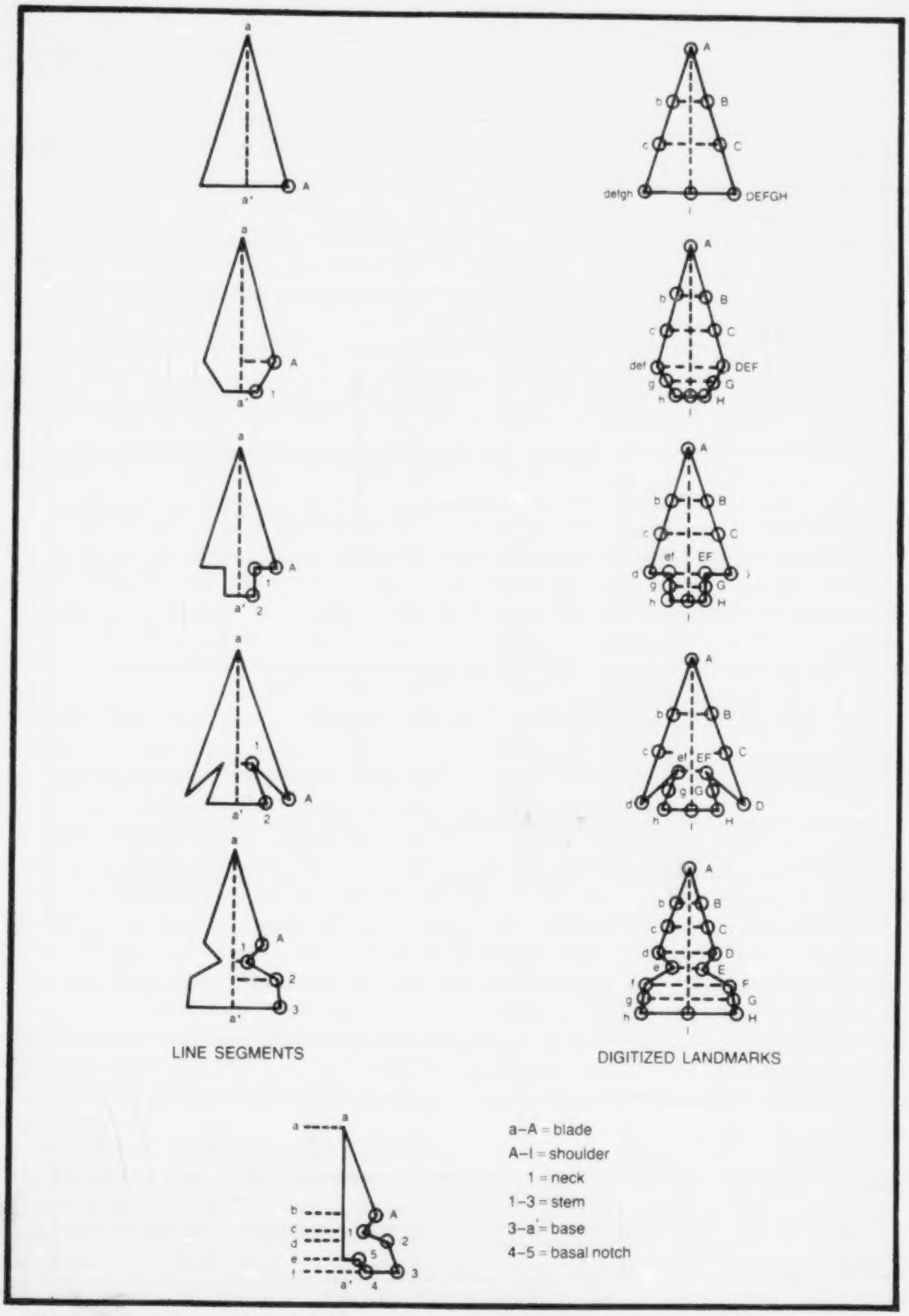

1. N1N1 Large Triangular
2. N1N2 Small Triangular
3. 1NN1 Large Side-notched
4. 1NN2 Small Side-notched
5. N2NN Lanceolate
6. 22NN Shouldered Lanceolate
7. 2121 Large, Shouldered Triangular contracting stem
8. 2122 Small, Shouldered Triangular contracting stem
9. 21(13)1 Large, Shouldered Triangular expanding and straight stem
10. 21(13)2 Small, Shouldered Triangular expanding and straight stem
11. 3121 Large, Squared Triangular contracting stem
12. 3122 Small, Squared Triangular contracting stem
13. 31(13)1 Large, Squared Triangular expanding and straight stem
14. 31(13)2 Small, Squared Triangular expanding and straight stem
15. 4121 Large, Barbed Triangular contracting stem
16. 4122 Small, Barbed Triangular contracting stem
17. 41(13)1 Large, Barbed Triangular expanding and straight stem
18. 41(13)2 Small, Barbed Triangular expanding and straight stem

Figure 11-1. Morphological projectile point types.


a
a'
A
1
2
3
4
5
b
c
d
e
f
g
h
i
B
C
D
E
F
G
H
defgh
DEFGH
def
DEF
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EF

LINE SEGMENTS

DIGITIZED LANDMARKS

a–A = blade
A–1 = shoulder
1 = neck
1–3 = stem
3–a' = base
4–5 = basal notch

Figure 11-2. Definition of projectile point form and placement of landmarks.

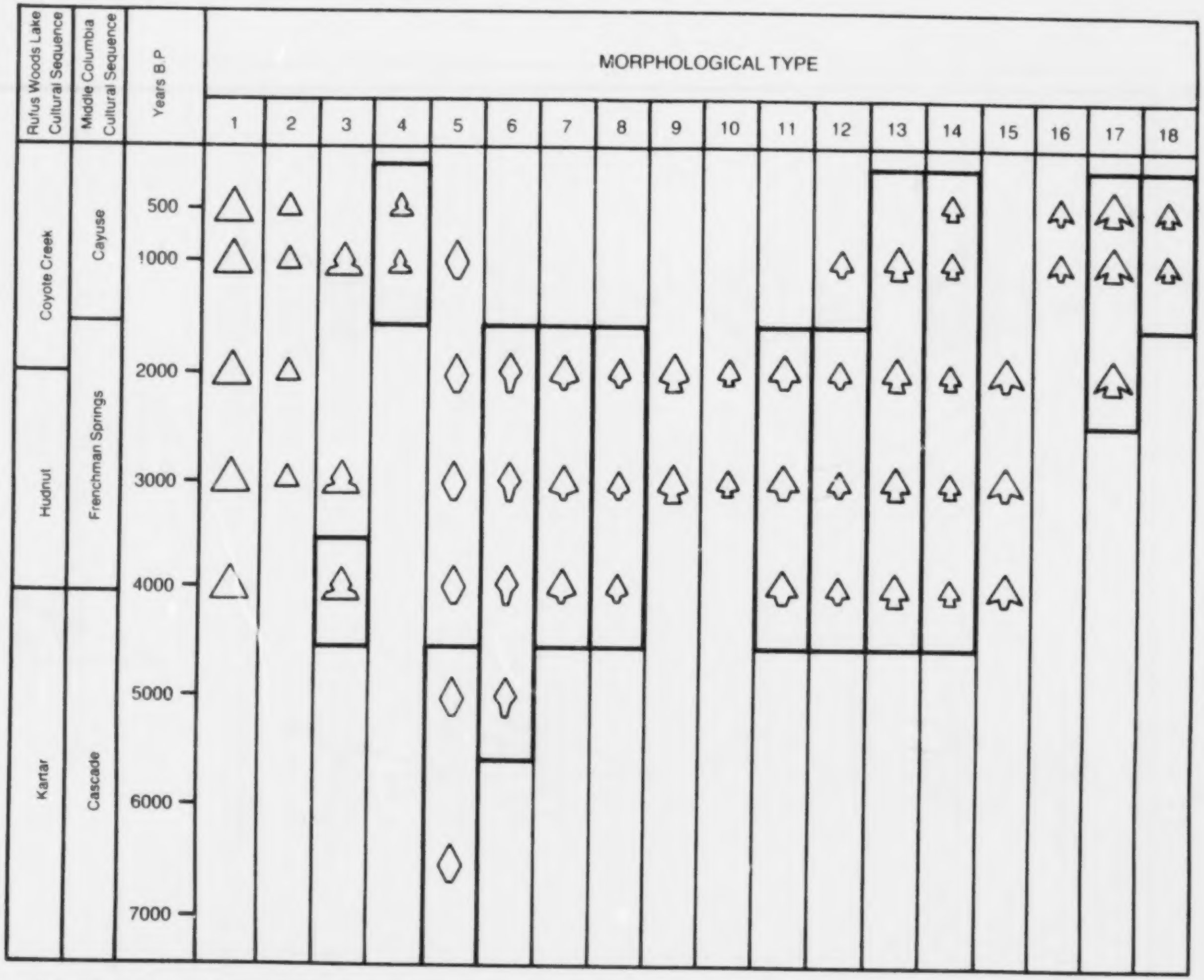


Figure 11-3. Temporal distribution of morphological types in the project area.

DISCRIMINANT ANALYSIS

Use of discriminant analysis produces an explicit, consistent classification with mathematically defined ranges of variability. Its use assumes the adequacy of prior type formulations, and simply speeds up the application of prior typologies. This analysis enables the researcher to quickly categorize a large collection, and offers a statisical basis for the definition of new types as well as an explicit definition of recognized types. When combined with the paradigmatic classification described above, discriminant analysis allows us to correlate the Rufus Woods Lake projectile point sequence with other chronologies in both a qualitative and quantitative manner. For a more complete discussion of this multivariate statistical method see Nie et al. (1975), Johnson (1978), and Klecka (1980).

SELECTION OF HISTORICAL TYPES AND TYPE ASSEMBLAGES

A review of the archaeological literature allowed us to identify twelve projectile point types with demonstrated or assumed historical sensitivity. I use the term "type" here, although some of these projectile point forms have never been explicitly defined. Table 11-2 lists the projectile point types and type variants used in this analysis. The type names are those commonly applied. The variant labels, although based on recognized variation in known types, are of our own invention. The types are grouped on the basis of haft treatment into six series, and on the basis of general outline into two divisions. The type numbers used in this report reflect the series divisions; note that they are different from the numbers used in the descriptive site reports (see Appendix I, Figure I-1 for correspondences).

Group autonomy was established for all the types and type variants listed in Table 11-2, except for the division of Quilomene Bar Corner-notched variants A and B. These proved to be very closely associated, and lacking any evidence of discrete temporal distribution, we combined the two variants into a single type, Quilomene Bar Corner-notched. Also, as will be discussed below, we have been audacious enough to define the previously poorly described large shouldered lanceolate point as the Mahkin Shouldered Type, and a recognized variant of Rabbit Island Stemmed as the Nespelem Bar Type. In both instances, type definition followed recognition of discrete temporal distributions for these forms in the archaeological record of the Rufus Woods Lake Reservoir.

Selection of projectile point collections for study was biased by factors of expediency. We selected those that (a) constituted the originally defined type specimens or contained specimens clearly identified by authors as recognized types or type variants, (b) were reasonably well-dated, and (c) were clearly illustrated to scale in published plates and figures. When possible, as in the case of Marmes Rockshelter, the Fraser River Drainage, and the Rufus Woods Lake Reservoir, specimens were handled, with measurements taken and paradigmatic codes applied.

We made no effort to randomly sample nor standardize the sample of specimens. From the outset, we assumed that the types exist, that correlations of formal attributes identified by prior researchers approach reality. At every juncture, we tried to assemble the largest number of type specimens possible. We wanted metric definitions sufficiently broad to ensure coverage of the postulated range of variation in form, and thereby be in a position to evaluate variation within type categories with an eye to recognition of significant variation not previously identified. In several instances, we subjectively selected specimens that to us represented characteristic examples of some types. We imposed type designations on specimens when authors failed to assign these to one of the recognized Columbia Plateau types. This subjectivity is not what we would have preferred, but it was inescapable for the very reason that this study assumes importance: there simply is no agreed upon projectile point typology for the Columbia Plateau.

Table 11-2. Historical projectile point types and type variants used in this analysis.

Division	Series	Point Types
Lanceolate	Lanceolate	Large unnamed Lanceolate (Type 11)[1]
		Windust C (Type 12)
		Cascade A (Type 13)
		Cascade B (Type 14)
		Cascade C (Type 15)
	Shouldered Lanceolate	Windust A (Type 21)[1]
		Windust B (Type 22)[1]
		Lind Coulee (Type 23)[1]
		Mahkin Shouldered (Type 24)[2]
Triangular	Side-notched Triangular	Cold Springs Side-notched (Type 31)
		Plateau Side-notched (Type 32)
	Corner-removed Triangular	Nespelem Bar (Type 41)[2]
		Rabbit Island A (Type 42)
		Rabbit Island B (Type 43)
	Corner-notched Triangular	Columbia Corner-notched A (Type 51)
		Quilomene Bar Corner-notched (Type 52)
		Quilomene Bar Corner-notched A
		Quilomene Bar Corner-notched B
		Columbia Corner-notched B (Type 53)
		Wallula Rectangular Stemmed (Type 54)
	Basal-notched Triangular	Quilomene Bar Basal-notched A (Type 61)
		Quilomene Bar Basal-notched B (Type 62)
		Columbia Stemmed A (Type 63)
		Columbia Stemmed B (Type 64)
		Columbia Stemmed C (Type 65)

1. Dropped out of analysis for final classification runs as no examples were identified in the Rufus Wood Lake project area.

2. Type defined based on distribution within the Rufus Woods Lake cultural sequence.

METRIC VARIABLES AND DISCRIMINANT ANALYSIS

Measurements used in discriminant analysis were taken from the two-dimensional outline of projectile point form. Either original illustrations or actual specimens were photocopied and landmarks placed at the selected points of measurement (position of landmarks shown on the right side of Figure 11-2). Landmarks were defined with a plotter (Hewlett Packard 721C), coordinates measured with a digitizer (Summagraphics Bit Pad One), and stored on a computer file (Cromemco System Three Microcomputer). Digitizing the projectile point outlines allowed us to develop a large data file of metric measurements that could be used to quickly characterize variation in morphology and to provide accurate depictions of artifact outlines.

Table 11-3 lists the point measurements derived from digitized data. Figure 11-4 illustrates the variables measured for each projectile point form. These were coded as distance, length, width, and angle measurements.

Discriminant analysis was used for two purposes. The first was to allow us to infer diagnostic elements of the defined historical types by exploring ways in which we could discriminate among groups on the basis of some set of characteristics. The second was to develop a consistent classification based on mathematical equations called "discriminant functions", which combine the group characteristics in a way that allows identification of the group which a given case most closely resembles. Both interpretation and classification are dependent upon identification of the discriminating variables.

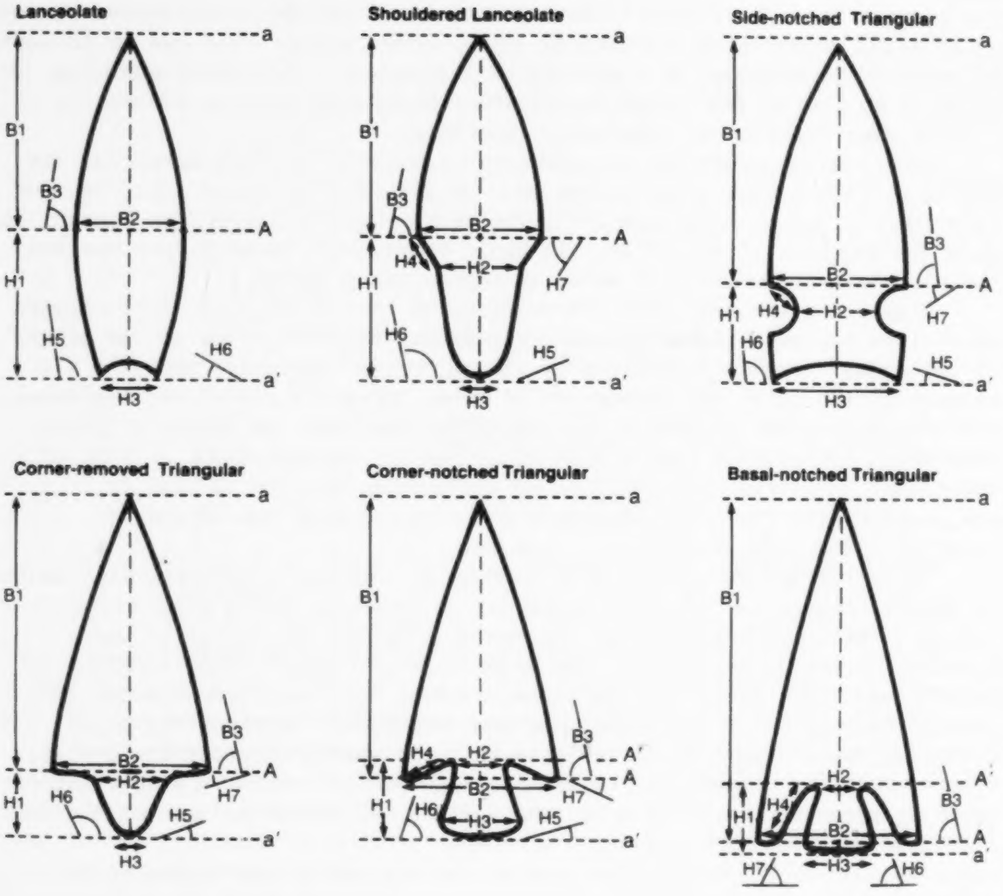
Canonical discriminant functions or linear combinations of the discriminating variables are formed, with the idea being to separate the group means as much as possible. The coefficients for each function maximize the differences between the group means, and each sequent function cannot have values correlated with values on the previous function. The maximum number of unique functions is equal to the number of groups in the analysis minus one, or the number of discriminating variables employed, whichever is fewer. Conceptually, the discriminating variables can be viewed as axes in n-dimensional space; each data case is a point in this space with coordinates that are the case's value on each of the variables. A centroid, representing the imaginary point whose coordinates are the group's mean on each of the variables measured, serves to summarize the position of each group within this n-dimensional space. No group's territory is identical with any other, athough considerable overlap may occur. Plots showing the dispersion of the group centroids can be used as an intuitive measure of the distinctiveness of the selected groups or of our ability to discriminate among the groups given the discriminating variables we have chosen to employ.

We can examine the correlation between variables by means of a correlation coefficient, standardized to vary between -1 and +1. A high correlation means that one score on one scale can be predicted fairly well by knowing the score on the other scale in that particular pair. Each correlation coefficient is an estimate of the strength of the relationship between the corresponding pair of variables within the group.

When we shift our focus from individual cases and group centroids to discovering the contribution of individual variables (relative importance), we can examine the magnitude of the standard coefficients (the larger the magnitude, the greater the variable's contribution). A discriminant function can be "named" on the basis of the structure coefficient by noting the variables having the highest coefficients. This is important for identifying

Table 11-3. Measurements recorded for projectile points.

MEASUREMENTS		
Blade Measurements		
B1.	Blade Length (.1mm). The distance from the blade-haft juncture (Node A) to the tip of the point, taken on the vertical axis a-a'.	BLL
B2.	Blade Width (.1mm). The distance from the widest point on the right lateral margin of the blade to the widest point on the left lateral margin of the blade.	BLW
B3.	Blade Angle (degrees). The outside angle between the blade-haft juncture and the margin of the blade (axis A and line segment aA). If the blade margin is markedly convex, the blade angle follows the lower section near the blade-haft juncture. Otherwise, it follows the general trend of the blade margin.	BLA
Haft Measurements		
H1.	Haft Length (.1mm). The distance from the lowest point on the basal margin to the blade-haft juncture (axis a' to A on vertical axis a-a').	HAL
H2.	Neck Width (.1mm). The distance from the point defining the blade-haft juncture on the right margin of the haft to the point defining the blade-haft juncture on the left margin of the haft (Node 1).	NEW
H3.	Basal Width (.1mm). The distance from the widest point on the right lateral margin of the base to the widest point on the left lateral margin of the base.	BAW
H4.	Shoulder Length (.1mm). The distance between A and A'. A' is not indicated on each drawing in Figure 11-4 but it is the axis along which the neck width (H2) is measured.	SHL
H5.	Basal Angle (degrees). The angle between the a' axis and the basal margin of the haft.	BAA
H6.	Basal Margin Angle (degrees). The angle between the a' axis and the lateral margin of the haft.	BMA
H7.	Shoulder Angle (degrees). The angle between the shoulder of the blade and axis A.	SHA
Other Measurements		
G1.	Thickness (.1mm). Thickness of the blade-haft juncture, taken on axis A. On lanceolate forms, this measure is taken between the widest lateral points on the blade. On triangular forms, it is taken at the neck.	
G2.	Weight (.1gm). This measure applies to whole specimens. Broken specimens may be included only if a reasonable estimate of the original size can be made.	
G3.	Total Length (.1mm). The distance between axis a and a' along vertical axis a'.	TOL
Ratios Calculated from Above		
R1.	Blade Length/Total Length	BLL/TOL
R2.	Neck Width/Basal Width	NEW/BAW
R3.	Basal Width/Blade Width	BAW/BLW


Lanceolate
Shouldered Lanceolate
Side-notched Triangular
Corner-removed Triangular
Corner-notched Triangular
Basal-notched Triangular
a
A
A'
a'
B1
B2
B3
H1
H2
H3
H4
H5
H6
H7

B1. Blade Length
B2. Blade Width
B3. Blade Angle
H1. Haft Length
H2. Neck Width
H3. Basal Width
H4. Shoulder Length
H5. Basal Angle
H6. Basal Margin Angle
H7. Shoulder Angle

Figure 11-4. Projectile point measurements.

the kind of information carried by the discriminant functions that is useful for discriminating among groups under consideration.

Discriminant functions are ranked by eigenvalues; the larger the value, the greater the discrimination afforded by the function. Eigenvalues can only be assessed relative to one another (6x greater, etc.). They can be converted to relative percentages as a measure of the amount of variance accounted for. There is no rule on how large the relative percentage must be before the discriminant function is considered important.

Canonical correlations are measures of association that summarize the degree of relatedness among groups and the discriminant function, from 0 or no relationship, up to a maximum of 1; the rule being the larger the number, the more the degree of association. In basic terms, this value judges how well the discriminant function is doing at separating groups.

Classification functions are constructed that allow us to sort unknown cases into the established groups. We can use these to check on the accuracy of our classification procedures by taking "known" cases and applying the classification rule; the proportion of cases correctly classified indicates the accuracy of the procedure and indirectly confirms the degree of group separation (cf. Klecka 1980). The proportion of "known" cases is also an additional intuitive measure of group difference, and can be used in conjunction with the canonical correlation to indicate the amount of discrimination supplied by the variables.

Specifically, we used an SPSS subprogram that utilizes a stepwise method to select the best set of discriminating variables by minimizing Wilke's lambda. The classification results tables provided the number of cases classified into each group and the percentage of correct classification for known cases. Statistics for each case include the discriminant score and classification, the probability of a case being that far from the group centroid, the probability of the case being in that group, and the probability of membership in the second closest group. Plots of cases were obtained locating group centroids in a scatter plot in n-dimensional space based on the first two discriminant functions.

The initial discriminant analysis run involved 23 historical projectile point types and type variants, represented by 726 specimens. Running all types together proved satisfactory, with over 80% of the cases correctly assigned, and demonstrating the rough autonomy of the identified types. However, visual examination of the type assignments showed some unwanted overlap in lanceolate and triangular forms, a basic division that we felt was imperative to keep clear. We therefore decided to run the lanceolate and triangular forms separately. The type assignments improved considerable. We also experimented with running the six major morphological series separately, omitting or adding variables as this seemed appropriate.

Figure 11-5 shows the separation of the six major type series, and Figures 11-6 through 11-11 show the distribution of identified types within these series as scores plotted on coordinates within n-dimensional space. As we expected, the six major morphological type series are quite distinctive, with the Lanceolate and the Side-notched morphological series showing the greatest spatial separation.

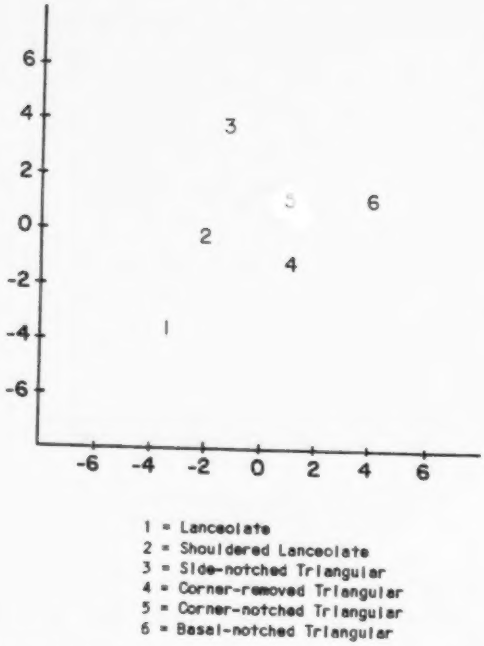


Figure 11-5. Plot of group centroids for the six major type series.

In the Lanceolate Series we found that Cascade Type variants A and C are closely grouped and very much distinct from the unnamed Large Lanceolate Type and the Cascade Type B variant and Windust Type C variant (Figure 11-6).

In the Shouldered Lanceolate Series, there is a clear separation of Windust Type A and Type B variants, both from each other and from the Lind Coulee Type and the Mahkin Shouldered Type (Figure 11-7). Conversely, the Lind Coulee Type and the Mahkin Shouldered Type appear closely related.

For Side-notched forms, we see that the Cold Springs Side-notched Type and the Plateau Side-notched Type are clearly differentiated (Figure 11-8).

Corner-removed Triangular examples are equally well separated (Figure 11-9), with visually identical distance between the Nespelem Bar Type and the Rabbit Island Type A and B variants.

Consideration of the Corner-notched Triangular Series shows the Quilomene Bar Corner-notched Type to be the most distinctive, although most closely related to the Columbia Corner-notched Type A variant (Figure 11-10). Both are distinct from the Columbia Corner-notched Type B variant and the Wallula Rectangular-stemmed Type.

Basal-notched Triangular Series forms show good separation as well (Figure 11-11), with the Columbia Stemmed Type A, B and C variants in a cluster set off from the Quilomene Bar Basal-notched Type A and B variants. The clear separation of variants within both of these types indicates the efficacy of the variant identification.

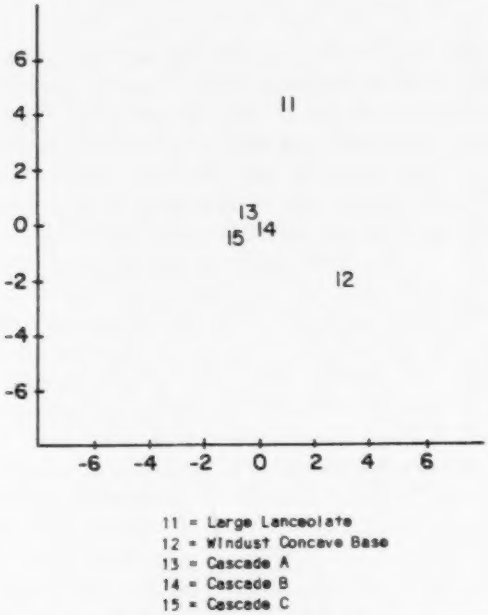


Figure 11-6. Plot of group centroids for the lanceolate type series.

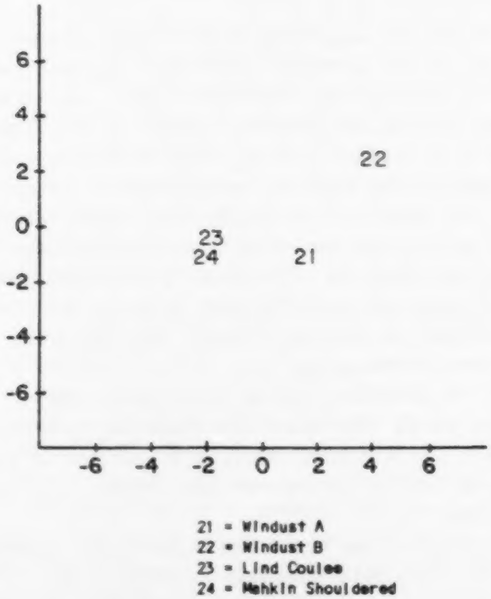


Figure 11-7. Plot of group centroids for the shouldered lanceolate type series.

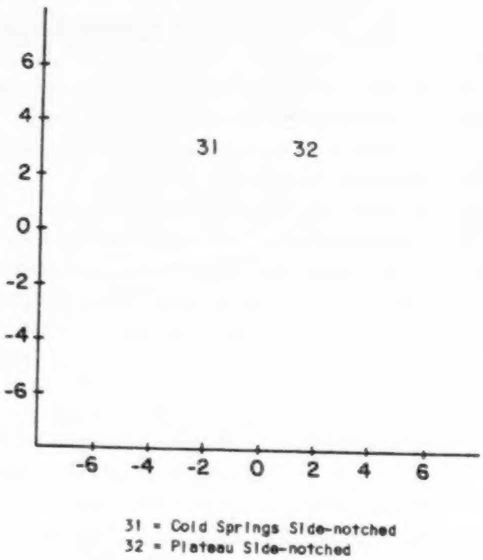


Figure 11-8. Plot of group centroids for the side-notched triangular type series.

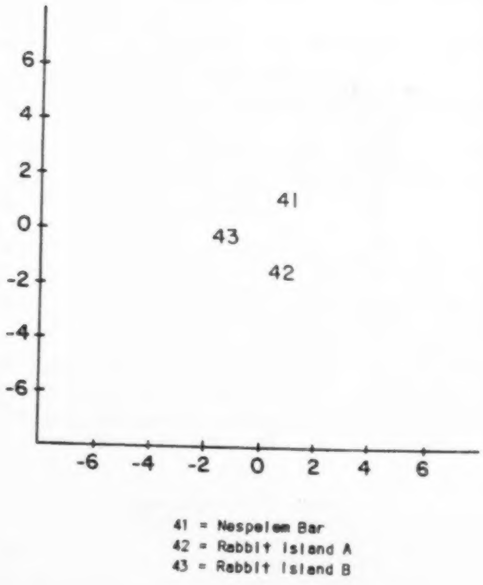


Figure 11-9. Plot of group centroids for the corner-removed triangular type series.

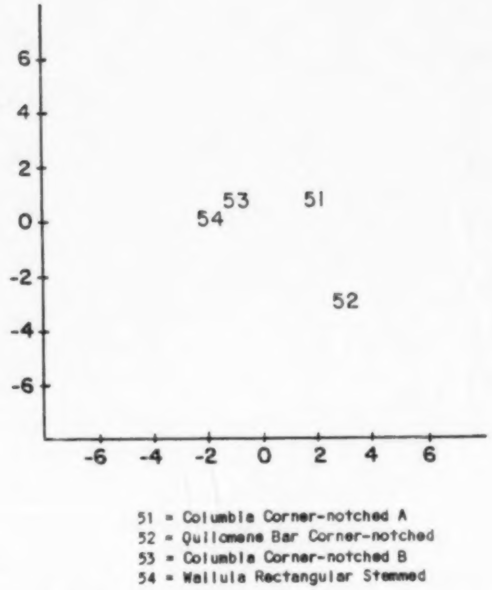


Figure 11-10. Plot of group centroids for the corner-notched triangular type series.

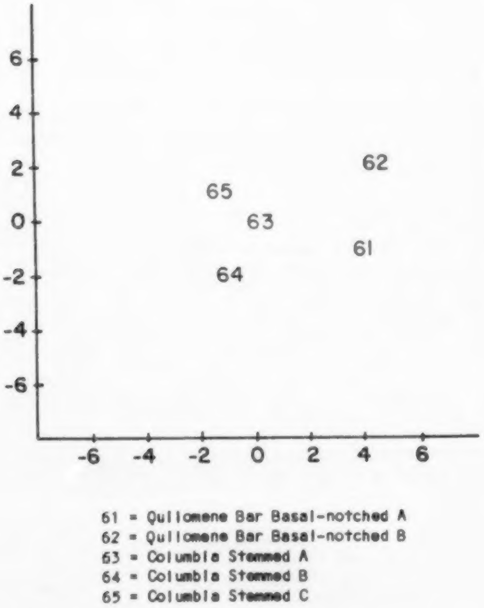


Figure 11-11. Plot of group centroids for the basal-notched triangular type series.

CLASSIFICATION OF RUFUS WOODS LAKE POINTS

Satisfied that we had selected a set of variables that provided adequate discrimination for cases with known memberships, we derived a set of classification functions that would permit classification of new cases with unknown memberships. In classifying the projectile points from the Rufus Woods Lake Reservoir, we retained the basic distinction between lanceolate and triangular forms, making two separate discriminant runs. We did not think it necessary nor advisable to make separate runs for the major morphological series. At this stage we were able to classify 80% of the lanceolate cases and 96% of the triangular cases (Tables 11-4 and 11-5).

Once these classification runs were accomplished, we sat down and manually sorted all of the classified projectile points into the designated type groups. Inconsistencies were noted, and the data checked for errors in digitizing or coding. Any errors were corrected, and the two runs performed again. At this stage, we also dropped out those early lanceolate and shouldered lanceolate types and type variants that were not represented in the Rufus Woods Lake collection, and once again combined lanceolate and triangular series to compare assignments with those produced previously. Changes in classification consisted primarily of shifts in the placement of large triangular and lanceolate forms with slight to moderately well-defined shoulders (ie, the Nespelem Bar Type and Mahkin Shouldered Type projectile points). Errors were minor, but we decided to preserve the fundamental distinction between lanceolate and triangular projectile points and produced a final classification run for each of the two divisions.

Table 11-4. Proportion of cases correctly classified in lanceolate run.

Group	Correct Group Assignment	%	Other Group Assignment	%
12	12	63.6	13	36.4
13	13	75.0	12 14	12.5 12.5
14	14	84.6	15 13	9.2 6.2
15	15	82.4	14	17.6
24	24	91.2	14	8.8

Table 11-5. Proportions of cases correctly classified in triangular run.

Group	Correct Group Assignment	%	Other Group Assignment	%
31	31	100.0		
32	32	100.0		
41	41	97.8	42	2.2
42	42	100.0		
43	43	92.5	42 51	5.0 2.5
51	51	100.0		
52	52	91.8	62	2.8
53	53	97.4	54	2.6
54	54	100.0		
61	61	100.0		
62	62	85.7	61	14.3
63	63	82.4	65 64	11.8 5.9
64	64	95.5	65	4.5
65	65	96.1	63	3.9

Tables 11-6 through 11-9 present the discriminant functions developed in these two runs; Tables 11-6 and 11-7 listing the standardized coefficients for the discriminating varables by functions, and Tables 11-8 and 11-9 listing the eigenvalues, percentage of variance explained, canonical correlations, and function "names". For lanceolate points, the first two discriminant functions (Function #1 Haft length; and Function #2 Neck width, blade width, shoulder angle, and shoulder length) account for 91% of the variance. For the triangular run (Function #1 Shoulder angle; Function #2 Basal margin angle; Function #4 Basal width, neck width/basal width ratio) account for 94% of the variance. Thus, not surprisingly, we see that haft construction, including stem and shoulder configuration and proportion, are the prime discriminating variables in defining the various historical projectile point types and type variants. For lanceolate points, haft length and the development of well-defined shoulders, coupled with blade and neck width, are the major variables, particularly reflective of shouldered/stemmed versus unshouldered lanceolate points, and broad, perhaps incipient shouldered, lanceolates versus narrow lanceolate points. By contrast, for triangular points, variance in form is often more subtle, the primary discriminating variables being shoulder angle (sloping, straight, contracting), basal margin angle (contracting, straight, expanding), and stem size or proportion, reflected in basal width and the ratio between neck and basal width.

Table 11-6. Rotated standardized discriminant function coefficients, lanceolate run.

Variable[1]	Function			
	1	2	3	4
HAL	1.62930*	0.58156	0.13644	0.09102
NEW	-0.66959	-2.13060*	0.04343	1.07933
BLW	-0.37854	1.87766*	-0.38004	0.14127
SHA	-0.58898	0.72942*	0.30114	0.18290
SHL	-0.14420	-0.56915*	-0.17645	0.02717
BAA	0.02954	-0.18451	1.15468*	0.05487
NEW/BAW	0.07543	-0.35943	0.09655	2.64092*
BAW	0.52040	-0.01949	0.75848	-1.39551*
BMA	0.90011	-0.29259	-0.12511	1.13013*
BLL/TOL	0.43699	0.36965	-0.06445	-0.71940*
BLA	0.20608	0.17725	0.16446	0.48153*

1. See Table 11-3 for explanation of variables.

* denotes discriminating variables.

Table 11-7. Rotated standardized discriminant function coefficients, triangular run.

Variable[1]	Function											
	1	2	3	4	5	6	7	8	9	10	11	12
SHA	1.13180*	0.00183	0.03359	0.20858	-0.57197	0.01006	-0.00756	-0.07875	0.21768	0.03210	-0.09212	-0.03190
BMA	-0.00064	1.36027*	0.12852	-0.26011	0.05277	-0.02028	-0.01979	0.05736	0.09122	0.02245	-0.04640	-0.32189
BAW	-0.11572	0.33209	0.11505	-2.03334*	-0.09268	0.14800	-0.03814	-0.07871	-0.15012	-0.03288	0.04412	-0.06517
NEW/BAW	0.10110	0.52094	1.08466	1.40953*	0.14359	0.08349	-0.03545	-0.03803	0.27880	-0.02842	-0.00215	-0.18255
BLW	0.09446	-0.09132	0.00106	0.15049	-4.34977*	0.11661	0.23066	-0.07928	0.00019	-0.11669	0.25335	0.05764
SHL	-0.05689	-0.14535	-0.08740	-0.03763	3.08862*	-0.12114	0.90264	-0.21675	-0.53091	-0.15621	0.48052	0.10480
NEW	0.06591	-0.14823	0.19949	1.57169	2.77475*	0.92467	-0.11186	-0.26420	-0.01335	-0.13457	0.15794	0.01070
BLL/TOL	0.20916	0.04786	0.06384	0.17178	-0.18875	0.00890	-0.05113	-0.03250	2.47302*	0.07675	-0.35578	-0.19827
BLL	0.10129	0.07017	-0.03038	-0.04591	0.43459	-0.06015	-0.06602	-0.00830	-1.57205*	1.11517	-0.68887	-0.08636
HAL	-0.22483	0.16694	-0.03474	0.00204	-0.54055	-0.09817	-0.07760	1.16386	1.53969*	-0.00735	-0.23112	-0.08540
BLA	-0.08857	-0.04636	-0.00141	0.00184	-0.31147	0.02453	0.05892	-0.08791	-0.50068	-0.15885	1.52621*	1.21344
BAA	-0.00304	-0.02869	-0.00603	-0.00007	-0.00837	0.00011	0.00213	-0.00314	-0.2937	-0.00315	0.01852	1.04840*

1. See Table 11-3 for explanation of variables.

* denotes discriminating variables.

Table 11-8. Canonical discriminant functions, lanceolate run.

Function	Eigenvalue	Percent of Variance	Cumulative Percent	Canonical Correlation	Discriminating Variables[1]
1	8.66516	72.68	72.68	0.9468556	HAL
2	2.25006	18.87	91.55	0.8320537	NBW, BLW, SHA, SHL
3	0.98569	8.27	99.82	0.7045537	BAA
4	0.02182	0.18	100.00	0.1461184	NBW/BAW, BAW, BHA, BLL/TOL, BLA

1. See Table 11-3 for explanation of variables.

Table 11-9. Canonical discriminant functions, triangular run.

Function	Eigenvalue	Percent of Variance	Cumulative Percent	Canonical Correlation	Discriminating Variables[1]
1	13.95126	52.28	52.28	0.9659783	SHA
2	5.99569	22.47	74.75	0.9257725	BHA
3	3.01689	11.31	86.06	0.8666323	–
4	2.09034	7.83	93.89	0.8224420	BAW, NBW/BAW
5	0.50275	1.88	95.78	0.5784076	BLW, SHL, NBW
6	0.46605	1.75	97.52	0.5638228	–
7	0.35922	1.35	98.87	0.5140852	–
8	0.16605	0.62	99.49	0.3773835	–
9	0.08742	0.33	99.82	0.2835417	BLL/TOL, BLL, HAL
10	0.03632	0.14	99.96	0.1872044	–
11	0.01170	0.04	100.00	0.1075613	BLA
12	0.00029	0.00	100.00	0.0171228	BAA

1. See Table 11-3 for explanation of variables.

Table 11-10 presents mean measurements for each of the discriminant type groups. All measurements given here, and in subsequent tables, are in tenths of millimeters (0.1 mm).

With type assignments now in hand, we then selectively correlated type specimens with recorded metric attributes and morphological codes, creating a series of tables outlining morphological, technological, and functional attributes of the historical projectile point types (Tables 11-11 and 11-12). Types also were arranged by cultural component; first by analytic zones within sites, and then by the three cultural phases defined for the project area and by associated radiocarbon dates (Table 11-13, Figure 11-12). The practical result is a temporal distribution of projectile point types comparable to those recognized for the Columbia Plateau, but defined statistically and assessed by reference to basic descriptive attribute analysis.

Table 11-10. Mean measurements for discriminant type groups.

Point Type	Measured Variables[1]											
	BLL (.1mm)	BLW (.1mm)	BLA deg.	HAL (.1mm)	NEW (.1mm)	BAW (.1mm)	SHL (.1mm)	BAA deg.	BNA deg.	SHA deg.	BLL/TOL	NEW/BAW
Lanceolate												
Windust C	210.00	76.27	78.21	141.18	76.14	41.84	1.42	106.85	110.06	90.00	0.60	0.56
Cascade A	267.12	82.72	81.86	169.10	82.87	20.78	1.48	82.82	122.19	90.00	0.62	0.25
Cascade B	263.25	73.94	82.18	173.00	73.94	35.94	1.42	106.06	109.19	90.00	0.60	0.49
Cascade C	273.30	64.06	83.41	169.24	64.62	8.34	1.72	85.70	120.46	90.00	0.62	0.13
Mahkin Shouldered	282.09	90.73	80.88	139.88	69.91	43.23	38.81	76.32	107.78	144.53	0.65	0.63
Triangular												
Cold Springs Side-notched	235.84	92.56	75.78	115.76	55.90	83.37	52.40	92.54	104.77	139.22	0.65	1.63
Plateau Side-notched	130.59	46.67	72.89	81.59	28.43	58.09	29.13	94.04	92.14	138.23	0.60	2.10
Nespelem Bar	241.58	74.63	80.71	80.23	55.63	33.05	29.43	74.41	116.49	136.54	0.75	0.61
Rabbit Island A	272.14	86.86	77.86	70.51	46.16	29.95	41.43	79.52	107.63	111.88	0.79	0.63
Rabbit Island B	273.66	74.24	76.27	66.58	42.34	13.75	36.65	81.20	122.21	120.44	0.80	0.34
Columbia Corner-notched A	213.06	92.14	73.64	84.63	51.50	60.04	45.18	80.21	74.69	119.07	0.71	1.18
Quilomene Bar Corner-notched	266.00	111.08	74.86	75.18	63.60	73.26	46.45	82.45	69.75	89.87	0.78	1.17
Columbia Corner-notched B	201.34	59.53	77.54	56.60	28.86	36.31	33.77	77.53	60.80	109.91	0.77	1.37
Wallula Rectangular Stem	205.75	64.00	78.19	52.91	26.65	27.22	38.07	75.37	82.22	79.66	0.80	1.03
Quilomene Bar Basal-notched A	345.27	123.75	79.16	60.20	58.17	59.27	75.62	81.67	77.28	62.72	0.90	1.06
Quilomene Bar Basal-notched B	245.36	126.07	60.32	78.92	56.00	60.57	71.20	78.57	71.78	73.46	0.80	1.26
Columbia Stemmed A	278.62	83.29	79.57	46.20	34.06	33.23	63.04	90.69	61.22	49.52	0.97	0.98
Columbia Stemmed B	324.02	98.48	72.56	45.36	34.45	30.46	71.60	91.41	83.37	60.10	0.96	0.91
Columbia Stemmed C	206.10	83.12	71.29	46.48	29.43	31.66	61.02	83.18	75.54	60.45	0.91	1.11

1. See Table 11-3 for explanation of variables.

Table 11-11. Attributes of flaking pattern.

Point Type	Flaking Pattern					
	Variable	Uniform	Mixed	Collateral	Transverse	Indeterminate
Windust C	66.7	-	33.3	-	-	-
Cascade A	43.6	3.6	39.9	10.9	1.8	-
Cascade B	60.0	-	40.0	-	-	-
Cascade C	63.2	5.3	21.1	10.5	-	-
Mahkin Shouldered	57.6	3.5	28.1	3.6	-	-
Cold Springs Side-notched	50.0	-	15.0	5.0	-	30.0
Plateau Side-Notched	70.3	4.7	12.5	-	-	12.5
Nespelem Bar	78.8	1.6	16.6	0.5	-	2.1
Rabbit Island A	74.2	6.2	14.1	0.8	-	4.7
Rabbit Island B	76.2	4.8	15.5	1.2	-	2.4
Columbia Corner-notched A	73.5	20.8	-	-	-	5.6
Quilomene Bar Corner-notched	67.9	-	17.8	-	-	14.3
Columbia Corner-notched B	79.1	5.2	12.4	1.0	-	2.0
Wallula Rectangular Stem	83.4	2.8	11.1	-	-	2.8
Quilomene Bar Basal-notched A	66.7	-	33.2	-	-	-
Quilomene Bar Basal-notched B	83.3	16.7	-	-	-	-
Columbia Stemmed A	57.1	14.3	28.6	-	-	-
Columbia Stemmed B	50.0	12.5	25.0	-	-	12.5
Columbia Stemmed C	76.2	7.9	13.1	-	-	2.6

Table 11-12. Attributes of cross section.

Point Type	Cross-Section				
	Planoconvex	Biconvex	Diamond	Trapezoidal	Indeterminate
Windust C	-	100.0	-	-	-
Cascade A	16.3	60.0	1.8	21.7	-
Cascade B	60.0	20.0	-	20.0	-
Cascade C	10.6	42.1	26.3	21.1	-
Mahkin Shouldered	12.8	59.9	7.1	21.1	-
Cold Springs Side-notched	10.0	80.0	-	5.0	5.0
Plateau Side-notched	7.8	87.1	-	1.6	1.6
Nespelem Bar	18.4	56.4	3.3	21.1	0.5
Rabbit Island A	13.5	72.6	3.2	9.4	1.6
Rabbit Island B	11.9	62.0	7.2	19.0	-
Columbia Corner-notched A	5.6	84.4	-	8.4	1.4
Quilomene Bar Corner-notched	6.8	79.2	-	10.3	3.4
Columbia Corner-notched B	18.7	78.1	-	2.0	1.0
Wallula Rectangular Stem	13.9	75.0	-	8.3	2.8
Quilomene Bar Basal-notched A	22.2	72.2	-	5.5	-
Quilomene Bar Basal-notched B	-	100.0	-	-	-
Columbia Stemmed A	-	100.0	-	-	-
Columbia Stemmed B	-	100.0	-	-	-
Columbia Stemmed C	15.7	84.2	-	-	-

Table 11-13. Temporal distribution of established projectile point types.

Site	Phase	Projectile Point Type																		
		12	13	14	15	24	31	32	41	42	43	51	52	53	54	61	62	63	64	65
All Excavated Sites	Coyote Creek	-	08.6	-	12.5	17.4	26.7	100.0	23.4	25.0	31.2	46.5	42.8	84.8	83.9	40.0	20.0	100.0	100.0	97.1
	Hudnut	-	14.8	-	37.5	18.8	33.3	-	67.6	71.6	59.4	44.8	52.4	15.2	12.9	60.0	80.0	-	-	2.9
	Kartar	100.0	76.6	100.0	50.0	63.8	40.0	-	9.0	3.4	9.4	8.8	4.8	-	3.7	-	-	-	-	-
45-OK-2	Coyote Creek	-	33.3	-	100.0	44.4	100.0	100.0	40.0	36.9	50.0	98.1	100.0	94.1	94.1	100.0	50.0	100.0	100.0	100.0
	Hudnut	-	66.6	-	-	55.6	-	-	60.0	63.1	50.0	1.9	-	5.9	5.9	-	50.0	-	-	-
45-OK-258	Coyote Creek	-	-	-	-	-	-	100.0	27.3	22.6	33.3	37.5	100.0	88.2	100.0	16.7	-	-	100.0	87.5
	Hudnut	-	100.0	-	-	100.0	-	-	72.7	77.4	66.6	62.5	-	11.8	-	83.3	-	-	-	12.5
45-OK-11	Hudnut	100.0	6.2	-	33.3	15.3	-	-	73.7	90.0	50.0	50.	100.	100.0	66.6	-	-	-	-	-
	Kartar	-	93.7	100.0	66.6	84.7	100.0	-	26.3	10.0	50.0	50.0	-	-	33.3	-	-	-	-	-

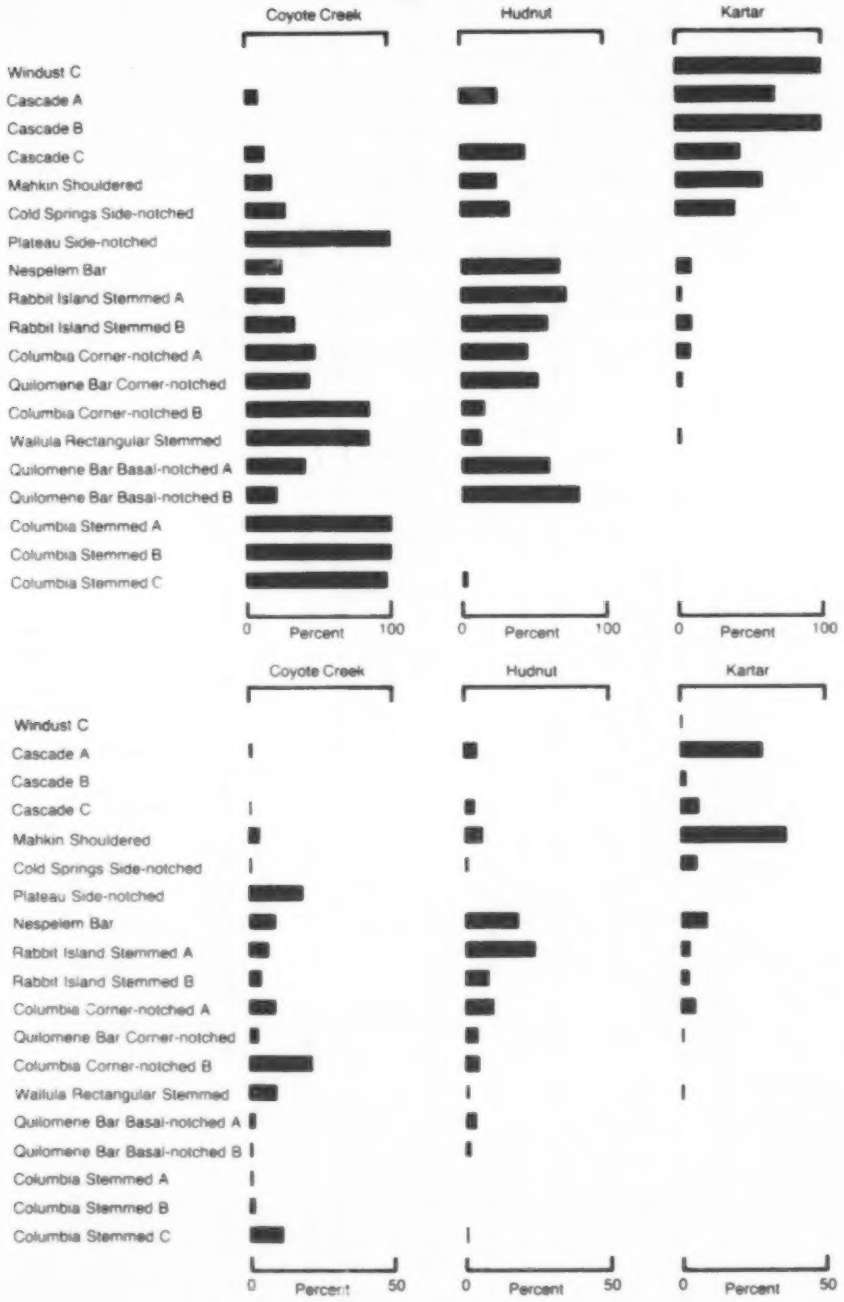


Figure 11-12. Relative frequency of historic types by phase.

PROJECTILE POINT TYPE DESCRIPTIONS

The following projectile point type descriptions are presented in outline form for the sake of convenience. The number of specimens listed refers to the number identified in the Rufus woods Lake assemblage. Descriptions of type and type variant attributes are based on accepted definitions, suffused where appropriate by data recovered from the study of Rufus Woods Lake points. Estimates of the temporal range of each type or type variant have been modified from the original published references, given chronological placements documented for the Rufus Woods Lake study area. Illustrations were selected from among the digitized outlines produced in our analysis to show the range of variation present in each type category. Specimens are arranged across the page from left to right in order of decreasing probability of assignment to the defined type. The key below each outline lists:

Site number / Master #

Probability of a case located this / Probability of group membership
distance from the group centroid

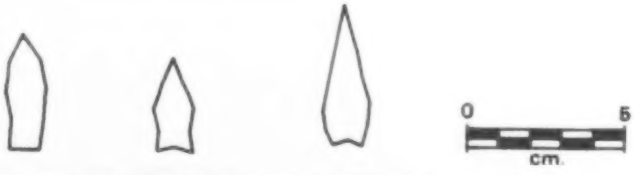
Second group assignment / Probability of assignment

Windust C (Type 12). N = 4

This variant of the Windust Type, which more typically is a squat, shouldered lanceolate form with a broad stem, has never been formally defined, but is a common element of Windust projectile point assemblages. It has been referred to as "Farrington Basal-notched" (Rice 1965). This type variant is a lanceolate point, squat and heavy in appearance, of variable outline, with a pronounced basal notch. Flaking patterns are variable to mixed, with specimens exhibiting a markedly biconvex cross-section.

Type Sites: Windust Caves (Rice 1965)
Marmes Rockshelter (Rice 1969, 1972)

Temporal Distribution: c. 10000?-7000 B.P.; early Kartar Phase



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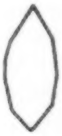
Cascade A (Type 13). N = 61

This is a common variant of the classic Cascade projectile point defined by Butler (1961, 1962, 1965). It is a broad, often thick lanceolate point with a rounded to pointed base. Flaking patterns are primarily variable to mixed, although collateral and transverse flaking are also present. Serrated margins are exhibited, but are not nearly as frequent as on the Cascade C variant. Cross-sections are usually biconvex or planoconvex, but trapezoidal cross-sections are common, and diamond cross-sections occur.

Type Sites: Indian Well (Butler 1961)
Wels Rockshelter (Butler 1962)

Temporal Distribution: c. 8000-4000 B.P.; Kartar Phase



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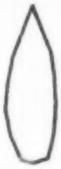

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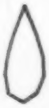

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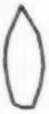

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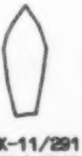
Cascade B (Type 14). N = 6

This variant of the Cascade Type does not occur frequently (cf. Rice 1969, 1972), and is morphologically closest to the Windust C type variant. A slender lanceolate point with a slightly concave base, it differs from the Windust C point in not having a marked basal notch. Also it is thinner with a more regular outline and cross-section, which gives it an almost delicate appearance. Flaking patterns are variable to mixed; serrated margins occur; and cross-sections are planoconvex, biconvex, and trapezoidal.

Type Sites: Marmes Rockshelter (Rice 1969, 1972)

Temporal Distibution: c. 8500-6500 B.P.; confined to the early Kartar Phase



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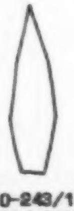

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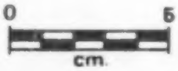
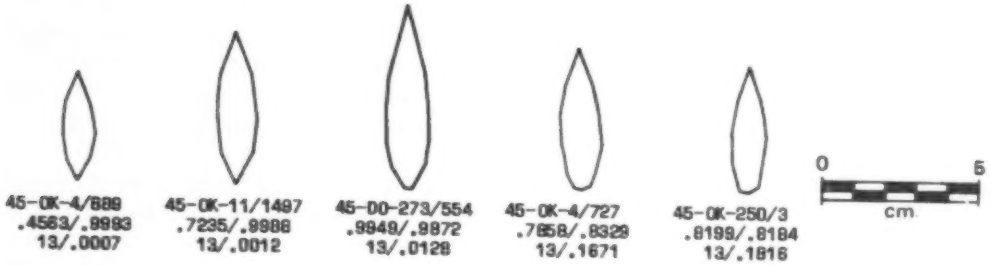


Cascade C (Type 15). N = 21

This is the classic Cascade Type defined by Butler (1961, 1962, 1965), a slender lanceolate point with a markedly contracting basal margin. Flaking patterns are usually variable, although tending toward mixed, and occasionally, collateral. Serrated margins are common. Cross-sections are primarily biconvex, but the Cascade C specimens show markedly higher frequencies of diamond and trapezoidal cross-sections than Cascade A and B type variants.

Type Sites: Indian Well (Butler 1961)
Weis Rockshelter (Butler 1962)

Temporal Distribution: c. 8000-4000 B.P.; principally Kartar Phase, but extending into the early Hudnut Phase

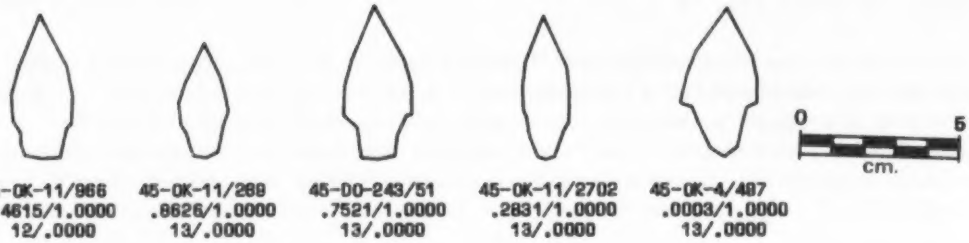


Mahkin Shouldered Lanceolate (Type 24). N = 93

A common form of projectile point recovered in excavations across the Columbia Plateau, this type has never been formally defined. This large shouldered lanceolate point of variable outline and proportion is often found in association with Cascade type variants and the Cold Spring Side-notched Type. It ranges from a very large point with a long, broad stem, similar to the defined Lind Coulee Type to a small, squat point very like the triangular Rabbit Island Stemmed type variants. Flaking patterns are generally variable to mixed, although examples of collateral and uniform flaking do occur. These forms are never serrated. Specimens characteristically have thick cross-sections, usually biconvex, but sometimes trapezoidal, planoconvex, or diamond-shaped.

Type Sites: Windust Caves (Rice 1965)
Marmes Rockshelter (Rice 1969, 1972)
45-OK-11 (Lohse 1984)

Temporal Distribution: c. 8000?-3500 B.P.; characteristic of the latter part of the Kartar Phase, but also found in early Hudnut Phase components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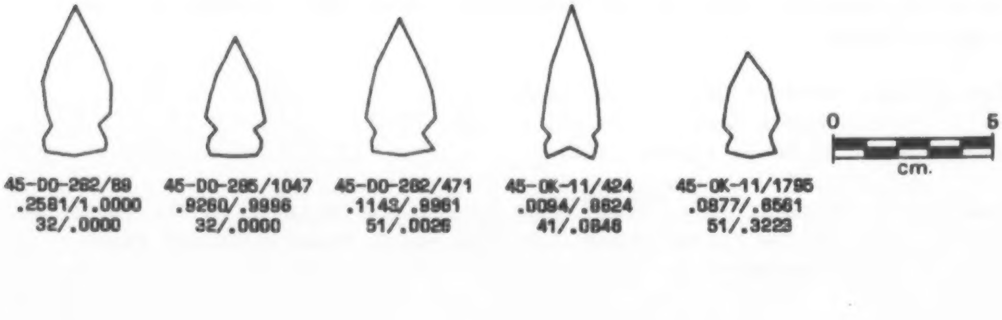
Cold Springs Side-notched Type (Type 31). N = 20

This large side-notched projectile point was first identified by Shiner (1961) and more fully defined and described by Butler (1962). Characteristic of of the latter part of the Cascade Phase (c. 7000-3500 B.P.), it is commonly associated with Cascade Type variants and the Mahkin Shouldered Lanceolate Type points. It is a large point form with deep to shallow lateral notches. Outline and proportion differ markedly, as does the treatment of the basal margins. Contracting lateral basal margins give the point a decidedly lanceolate outline, while straight lateral margins indicate manufacture on a triangular blank. Some of the smaller examples may resemble large versions of the Plateau Side-notched point or Columbia Corner-notched Type. In general, the Cold Springs Side-notched Type has notches placed higher up on the lateral point margins than the later Plateau Side-notched examples and is never basally notched. Flaking pattern is generally classified as variable, although examples of mixed and collateral flaking do occur. None are serrated. Cross-sections are predominantly biconvex, with a few specimens having planoconvex or trapezoidal cross-sections.

Type Sites: Cold Springs (Shiner 1961)
Weis Rockshelter (Butler 1962)

Temporal Distribution: c. 7000-3500 B.P.; characteristic of the Kartar Phase, but examples also found in the Hudnut and Coyote Creek Phases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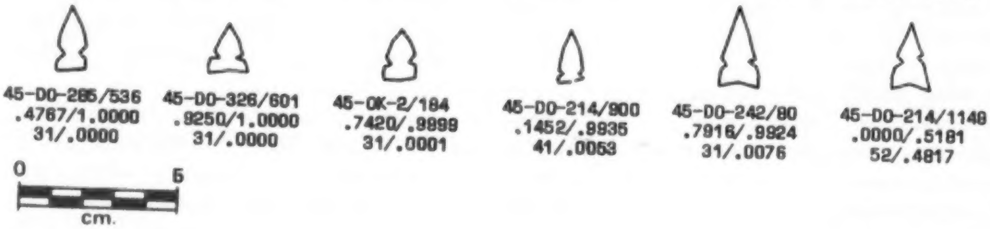
Plateau Side-notched Type (Type 32). N = 72

This small side-notched projectile point type is quite distinct from the larger Cold Spring Side-notched Type, and does not appear to be historically related to that earlier side-notched form, at least in the archaeological record of the Columbia Plateau (cf. Butler 1962). These smaller points show none of the marked tendancy toward convex blade margins exhibited by the Cold Springs Side-notched Type, and generally the side notches are placed lower along the lateral margins. Also, basal treatment in the Plateau Side-notched Type is far more variable, with markedly convex, concave, and notched bases, and straight to contracting lateral basal margins. It is a small, delicate point, usually highly symmetrical, and has a characteristic winged appearance. Flaking pattern is predominantly variable, with some examples of mixed. Serrated blade margins occur, but infrequently. Cross-sections are almost entirely biconvex.

Type Sites: None. This projectile point type has a wide distribution across all of western North America, and the labels small side-notched, Desert Side-notched Plateau Side-notched and Columbia side-notched have generally been applied without comment.

Temporal Distribution: c. 1500-0 B.P.; confined to the Coyote Creek Phase

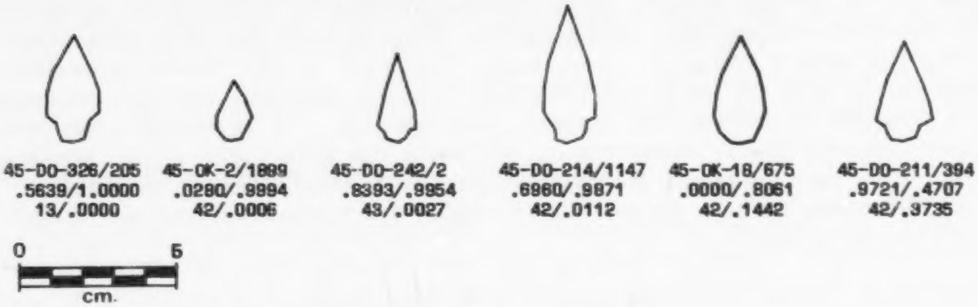


Nespelem Bar Type (Type 41). N = 198

A slightly shouldered triangular projectile point, this form has previously been subsumed under the Rabbit Island Stemmed Series as a common, although indistinct, variant (cf. Nelson 1969). Recovery of a substantial number of these projectile point forms in good, dated stratigraphic context in the Rufus Woods Lake project area has prompted us to define these as a distinct type, related to the Rabbit Island Stemmed Series, but clearly transitional between that point series and the earlier Mahkin Shouldered Lanceolate Type. These points are triangular with weak to strongly defined upward sloping shoulders, and generally thick, irregular cross-sections. The earliest forms are large, approaching the size of the Mahkin Shouldered Type, and are distinguished from those forms solely on the basis of their obvious triangular outline. Later versions are smaller, comparable in size to the Rabbit Island A examples, but are distinguished from that type by their rougher manufacture, irregular flaking pattern, and blocky cross-section.

Type Sites: 45-OK-11 (Lohse 1984)
45-OK-258 (Jaehnig 1984)

Temporal Distribution: c. 5000-3000 B.P.; spans the late Kartar Phase and the early to middle Hudnut Phase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42/.0006
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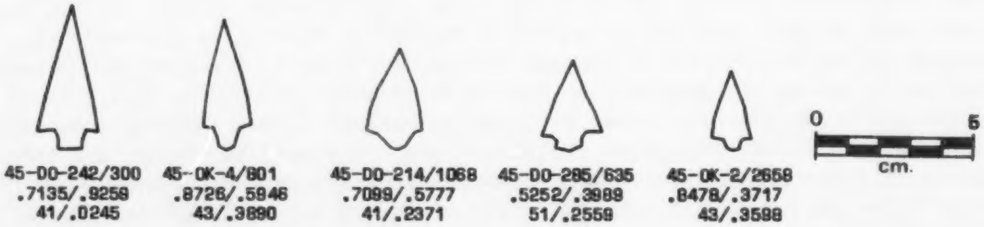
43/.0027
45-DO-214/1147
.6960/.9871
42/.0112
45-OK-18/675
.0000/.8061
42/.1442
45-DO-211/394
.9721/.4707
42/.3735
0
5
cm.

Rabbit Island Stemmed A (Type 42). N = 140

First identified by Daugherty (1952) and Crabtree (1957), and more fully described by Swanson (1962) and Nelson (1969), this point type is common across the central and northern Columbia Plateau at c. 4000 B.P., a period of time thought by many researchers to mark the beginning of sedentary village living along the Columbia River drainage (e.g., Nelson 1973). It is a distinctive, nicely made, thin triangular form with square shoulders, well-defined straight to contracting stems, generally regular. Cross-sections are predominantly biconvex. Serrated margins are frequent. Temporal distribution overlaps somewhat with both the Nespelem Bar Type and the Columbia Corner-notched A Type.

Type Sites: Shalkop Site (Swanson 1962)
Sunset Creek Site (Nelson 1969)

Temporal Distribution: c. 4000-2000 B.P.; confined to the Hudnut Phase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43/.3890
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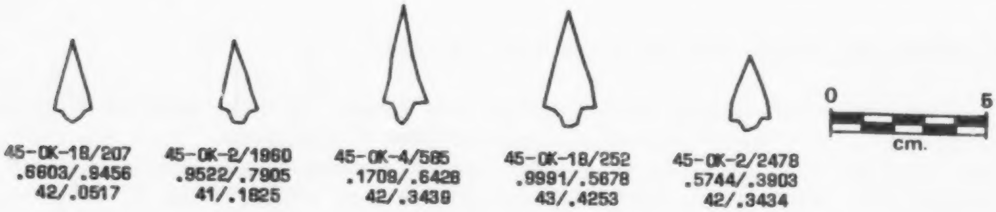
.7099/.5777
41/.2371
45-DO-285/635
.5252/.3989
51/.2559
45-OK-2/2658
.8478/.3717
43/.3598
0
5
cm.

Rabbit Island Stemmed B (Type 43). N = 95

This smaller, more delicate version of the Rabbit Island Stemmed point type has not been formally defined, but consistently occurs in later cultural contexts than the Rabbit Island Stemmed A. It is a small triangular projectile point, with square shoulders, straight to slightly incurvate lateral blade margins, and sharply contracting stems. Short lateral tangs at the juncture of blade and shoulder are common. Blade margins often are serrated. Flaking patterns are regular. Cross-sections are biconvex.

Type Sites: Shalkop Site (Swanson 1962)
Sunset Creek Site (Nelson 1969)
Wanapum Dam (Greengo 1982)

Temporal Distribution: c. 3000-1500 B.P.; confined largely to the latter part of the Hudnut Phase, but occurring in the early Coyote Creek Phase

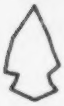


Columbia Corner-notched A (Type 51). N = 77

These are large, triangular points with straight to slightly convex lateral blade margins, and wide, deep corner notches producing thick, expanding stems and downward projecting shoulders. Flaking patterns are variable, but tend to be regular. Serrated blade margins are not present. Cross-sections tend to be thick, but generally are regular biconvex. Nelson (1969) and Leonhardy (1970) have produced the fullest descriptions of these forms, and document rough contemporaneity with the Rabbit Island Stemmed A point. Columbia Corner-notched points, although well-represented in the Rufus Woods Lake project area, were not frequent in cultural components containing Rabbit Island Stemmed forms. This appears to be consistent with their known spatial distribution: Columbia Corner-notched points are characteristic of the period from c. 4000-2000 B.P. on the southern Columbia Plateau, while Rabbit Island Stemmed points are more frequent over the same period on the central and northern Columbia Plateau. Although spatial overlap occurs, data from Rufus Woods Lake indicates that site populations tended to use one or the other. We suggest these are distinctive types with distinct cultural distributions.

Type Sites: Marmes Rockshelter (Rice 1969, 1972)
Granite Point Locality (Leonhardy 1970)
Sunset Creek Site (Nelson 1969)
Wanapum Dam (Greengo 1982)

Temporal Distribution: c. 4000-2000 B.P.; confined to the Hudnut Phase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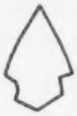
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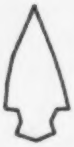
52/.0553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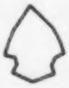
52/.1318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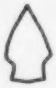
52/.1544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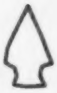
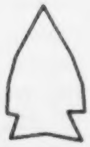

45-OK-18/661
53/.4111

Quilomene Bar Corner-notched (Type 52). N = 34

Quilomene Bar Corner-notched points are larger and more massive than the morphologically similar Columbia Corner-notched A specimens. They are big, heavy points, with straight to slightly convex lateral blade margins, deep, broad corner notches, and markedly expanding, thick stems. Flaking patterns are variable, but tend toward regular. Margins are not serrated. Cross-sections are usually biconvex, but may be somewhat trapezoidal or irregular. First defined by Nelson (1969), this point type is thought to come into the archaeological record somewhat later than the Columbia Corner-notched or the Rabbit Island A types, at c. 3000 B.P. Nelson (1969) suggests that these forms continue well past 2000 B.P., with the latest examples having a basally notched stem.

Type Sites: Marmes Rockshelter (Rice 1969, 1972)
Sunset Creek Site (Nelson 1969)
Wanapum Dam (Greengo 1982)

Temporal Distribution: c. 3000-2000 B.P.; confined to the latter part of the
Hudnut Phase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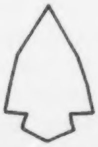
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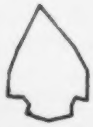
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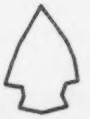
81/.0719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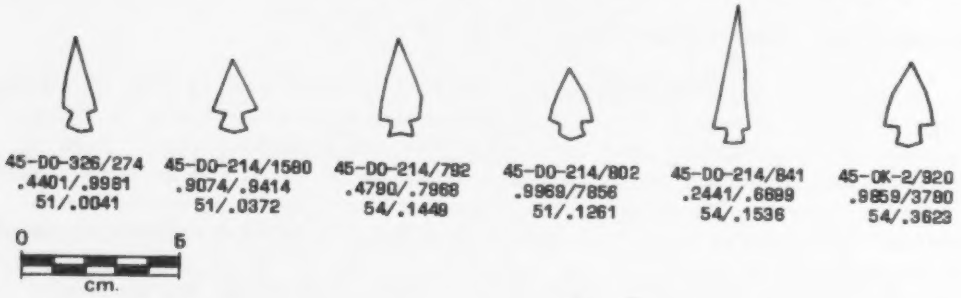
51/.2051

Columbia Corner-notched B (Type 53). N = 108

These are smaller versions of the Columbia Corner-notched A Type, and show little difference in outline or surface treatment. They are small triangular projectile points with straight to slightly convex lateral blade margins, deep corner notches, and expanding stems with straight to slightly convex basal margins. Flaking patterns are generally regular. Cross-sections are biconvex to planoconvex. Serrated blade margins are rare. These forms characterize the past 2,000 years of the archaeological record, representative of a carry-over of the Columbia Corner-notched Type into the Coyote Creek Phase of the Rufus Woods Lake project area.

Type Sites: Granite Point Locality (Leonhardy 1970)
Sunset Creek Site (Nelson 1969)
Wanapum Dam (Greengo 1982)

Temporal Distribution: c. 2000-150 B.P.; confined to the Coyote Creek Phase

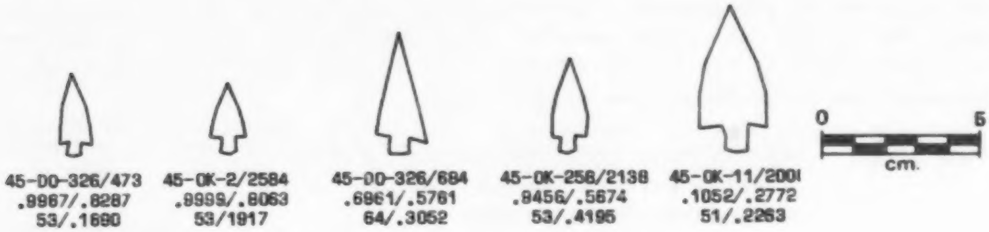


Wallula Rectangular Stem (Type 54). N = 41

These are distinctive, small, delicate triangular projectile points, with straight lateral blade margins, wide, low corner notches, long, straight-sided stems, and straight to very slightly convex basal margins. Flaking patterns are variable. Cross-sections tend to be biconvex. Osborne et al. (1952) and Crabtree (1957) first described this projectile point form; however, Shiner (1961) was the first researcher to explicitly define this form as a type. Crabtree (1957) had initially suggested it was historically related to the Rabbit Island Stemmed types and Shiner (1961) later postulated that Wallula Rectangular Stem points bridged the typological gap between the Rabbit Island Stemmed type and the Columbia Stemmed Series. Their temporal distribution in the Rufus Woods Lake project area reinforces the possibility that this projectile point type may represent a historical connection between the early Rabbit Island Stemmed series and the later Columbia Stemmed series. The Wallula Rectangular Stemmed Type is most common on the lower reaches of the Columbia River drainage, but does occur in very limited numbers at least as far north as Kettle Falls.

Type Sites: Sunset Creek Site (Nelson 1969)
Wanapum Dam (Greengo 1982)

Temporal Distribution: c. 2000-150 B.P.; confined to the Coyote Creek Phase with the exception of the aberrant specimen from 45-OK-11 (Master Number 2000).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53/1917
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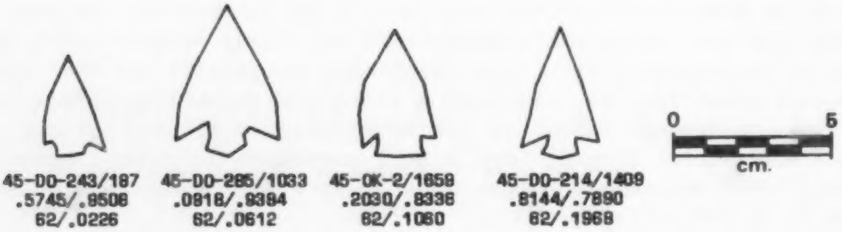
64/.3052
45-OK-256/2138
.8456/.5674
53/.4195
45-OK-11/200
.1052/.2772
51/.2263
0
5
cm.

Quilomene Bar Basal-notched A (Type 61). N = 23

These are large, thick, heavy projectile points, with convex to straight blade margins. Characteristically, the blade margins terminate in thick, squared, barbs extending down to the base of the expanding stem. Flaking patterns tend to be variable, although examples of mixed and uniform flaking are not uncommon. The majority of specimens have regular biconvex cross-section. Most fully described by Nelson (1969), this type appears to enter the archaeological record of the Columbia Plateau at about 2500 B.P., and, together with the Quilomene Bar Basal-notched B, continues for at least another 1,000 years. A very distinctive point type, it has no logical precedents in the defined projectile point typology. Possibly, as suggested by Nelson, it may relate to the later Columbia Stemmed Series.

Type Sites: Granite Point Locality (Leonhardy 1970)
Sunset Creek Site (Nelson 1969)
Wanapum Dam (Greengo 1982)

Temporal Distribution: c. 2500-1500 B.P.; spans the transition from the late Hudnut Phase to the early Coyote Creek Phase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62/.0612
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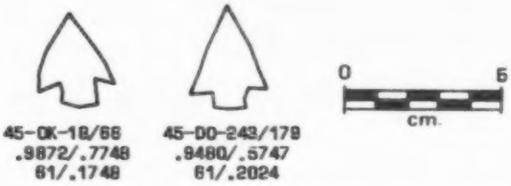
.2030/.8336
62/.1060
45-DO-214/1409
.8144/.7890
62/.1968
0
5
cm.

Quilomene Bar Basal-notched B (Type 62). N = 6

These specimens are virtually identical to the Quilomene Bar Basal-notched A described above. Major differences entail smaller overall size, and a tendency for barbs to be less square and shorter. Although statistically distinct, they could easily be interpreted as variants within the normal production sequence of the Quilomene Bar Basal-notched type. Flaking pattern is primarily variable, although several examples of uniform flaking were noted. Cross-sections are biconvex. Temporal range is identical to that observed for the Quilomene Bar Basal-notched A.

Type Sites: Sunset Creek Site (Nelson 1969)
Wanapum Dam (Greengo 1982)

Temporal Distribution: c. 2500-1500 B.P.; late Hudnut Phase to early Coyote Creek Phase

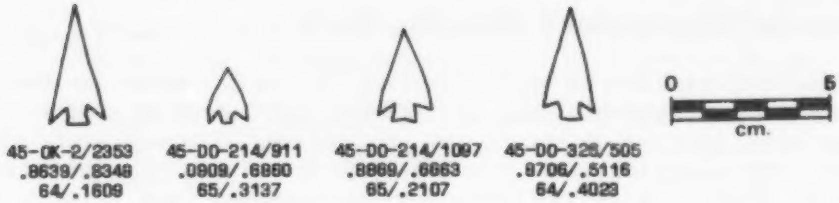


Columbia Stemmed A (Type 63). N = 7

In contrast to the Quilomene Bar Basal-notched Series, the Columbia Stemmed forms are delicate, elongate triangular forms with sharply pointed, downward projecting barbs, and small, narrow, slightly expanding stems. The Type A variant examples are long and narrow, with generally straight to very slightly concave lateral blade margins. Squared barbs do occur, but are not massive in proportion to point size. Flaking patterns are primarily mixed, but also include variable and uniform. Cross-sections are entirely biconvex and very regular. Most common on the lower Columbia River drainage, the Columbia Stemmed Series is nevertheless well-represented at least as far north as Kettle Falls. According to Nelson (1969, 1973), it coincides with increases in population density and the development of large winter villages culminating in the ethnohistoric record for the Columbia River. Given the center of distribution for this type on the lower Columbia River, it may be indicative of a northward expansion of population during the last 2,000-1,500 years.

Type Sites: Sunset Creek Site (Nelson 1969)
Wanapum Dam (Greengo 1982)

Temporal Distribution: c. 2000-150 B.P.; confined to the Coyote Creek Phase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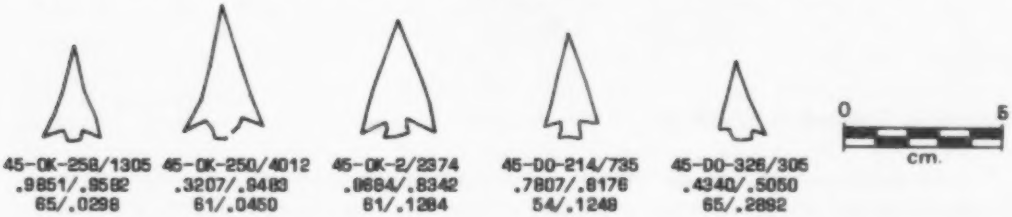
65/.2107
45-DO-328/505
.8706/.5116
64/.4023
0
5
cm.

Columbia Stemmed B (Type 64). N = 7

These specimens are very similar to the Type A variants, with distinctions resting primarily on more open basal notches, a lack of squared barbs, and a tendency for concave lateral blade margins. Flaking patterns are generally variable or mixed. Cross sections are uniformly biconvex. There is no apparent difference between Type B and Type A temporal distributions.

Type Sites: Sunset Creek Site (Nelson 1969)
Wanapum Dam (Greengo 1982)

Temporal Distribution: c. 2000-150 B.P.; confined to the Coyote Creek Phase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61/.1284
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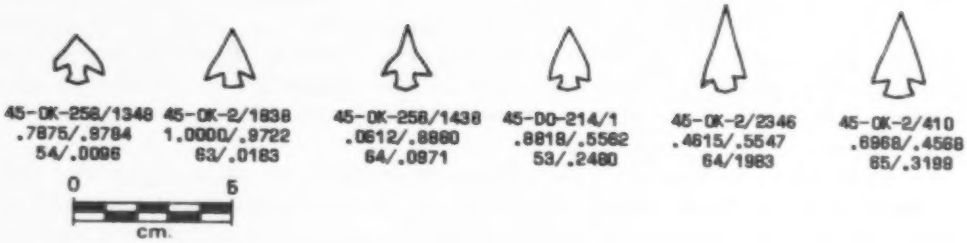
54/.1248
45-DO-326/305
.4340/.5050
65/.2892
0
5
cm.

Columbia Stemmed C (Type 65). N = 40

Type C variants are quite similar to both Type A and B variants, being small, delicate, triangular forms with distinctive basal notches and barbs. These specimens, however, tend to be smaller, more squat, and have open basal notches, with barbs laterally expanding rather than downward projecting. Lateral blade margins are somewhat variable, but tend toward straight. Flaking patterns are predominantly variable, with some examples of uniform and mixed. Cross-sections are generally biconvex, although planoconvex is also represented. These specimens appear to occur slightly later in time, consistent with the general dimunition in size through time noted by various researchers for projectile points in the archaeological record of the Columbia Plateau.

Type Sites: Sunset Creek Site (Nelson 1969)
Wanapum Dam (Greengo 1982)

Temporal Distribution: c. 1500-150 B.P.; middle to latter part of the Coyote Creek Phase



TEMPORAL DISTRIBUTION

Some practical considerations must be inserted into our discussion at this point, which properly qualify the identification of temporal trends in the distribution of defined projectile point types. Archaeological site deposits were dug within 10 and 5 cm arbitrary levels, provenienced within 1 x 1-m horizontal units. Stratigraphic control was preserved by recording identifiable cultural and natural profiles drawn on unit walls arranged along transects laid out to define site stratigraphy over north-south and east-west axes. In the lab, analytic zones were constructed that approximated perceived cultural layers. These were defined by assessment of relative densities observed in the distribution of artifact classes, recorded cultural and natural layers of deposition, and excavators' field notes. In turn, these analytic zones were arranged into three cultural phases based on discrete temporal distributions of certain artifact classes, distinctive cultural features, and radiocarbon dates. Overlap in artifact and feature distribution was unavoidable, most particularly in the more complex housepit sites and in site areas showing consistent reuse and resultant disturbance of site deposits over relatively short periods of time. However, if considered as macro units of time and as very ill-defined units of cultural change, the three phase designations provide a usable, pragmatic basis for cultural reconstruction.

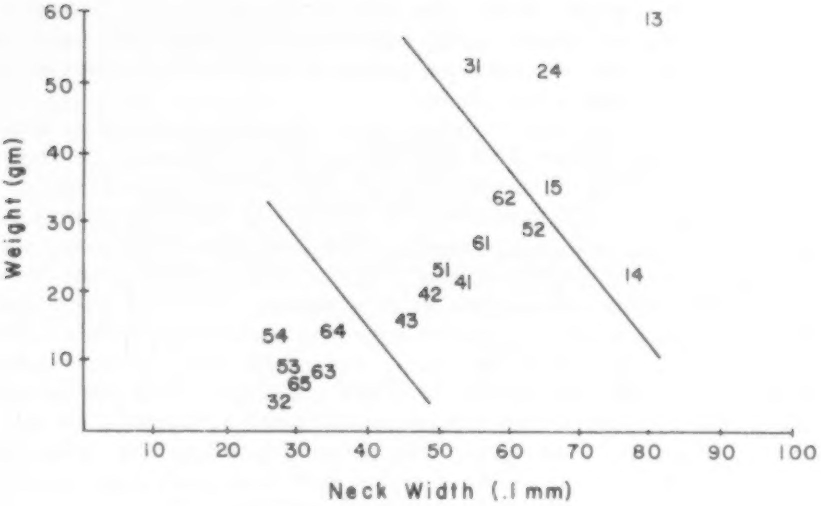
As noted above, several projectile point types are diagnostic of specific cultural phases. The earliest temporal period, the Kartar Phase (c. 6500-4000 B.P.), is characterized by Cascade Type variants, the Cold Springs Side-notched Type, the Mahkin Shouldered Type, and early, crude versions of the Nespelem Bar Type. The subsequent Hudnut Phase (c. 4000-2000 B.P.), is marked by the presence of the Nespelem Bar Type, Rabbit Island Stemmed Type A, the Columbia Corner-notched Type A and Quilomene Bar Corner-notched and Basal-notched varieties. The latest period, the Coyote Creek Phase (c. 2000-1150 B.P.), has the widest variety of projectile point forms, with the Rabbit Island Stemmed B, Columbia Corner-notched B, the Quilomene Bar Types, Wallula Rectangular Stemmed Type, the Columbia Stemmed Series, and the Plateau Side-notched Type. Of these, the Rabbit Island Stemmed B and the Quilomene Bar Corner-notched and Basal-notched varieties appear to be the earliest, marking a transition from the earlier Hudnut Phase. Distributions of these types within the defined cultural phases are fairly well-defined. Some blurring of the temporal boundaries can be attributed to mixing during site formation in the sandy, complex cultural deposits, mixing in excavation, mixing in zoning, and collecting of older points by site inhabitants. In those sites exhibiting well-defined cultural horizons, with discrete cultural features and artifact distributions marked by long intervals of non-occupation or shifts in site use causing little disturbance of cultural deposits, the basic temporal pattern of point types is quite clear.

Table 11-13 shows the distribution of projectile point types as relative frequencies by cultural phase for all sites in the Rufus Woods Lake project area, and as distributions within the major housepit sites marking each of the cultural phases: 45-OK-2 (Coyote Creek Phase), 45-OK-258 (Hudnut Phase), and 45-OK-11 (Kartar Phase). As shown, there is very little overlap in the temporal distribution of projectile point types, particularly within the larger divisions of type series. Predictably, the most severe overlap occurs in those point types with the lowest frequencies. It appears that as sample size increases, the temporal distribution of projectile point types becomes more discrete.

If we assume that not all overlap in the temporal distribution of point types is due to blurring of site stratigraphy, either by excavation methods employed or cultural processes active in site formation, we can postulate that the overlap may in part reflect cultural continuity. It seems entirely possible that certain point types can be combined into series of related forms that maintained popularity and were modified to some extent with the passing of time. For example, I am willing to postulate that the Mahkin Shouldered and Nespelem Bar Types are related forms: that the Mahkin Shouldered Type appeared in the late Kartar Phase, and that the Nespelem Bar Type is a direct output of the manufacture of the type, i.e., that the trend over time or the transition from the Kartar Phase to the Hudnut Phase is marked by the diminution of blade size of these shouldered points and the increasing definition and size reduction of the stem. Relatedly, I suggest that the Mahkin Shouldered-Nespelem Bar continuum emerges later as the defined Rabbit Island Stemmed Series during the middle and late Hudnut Phase and continues into the Coyote Creek Phase, and that this series of related forms represents a consistent, ongoing cultural tradition.

FUNCTIONAL AND TECHNOLOGICAL INTERPRETATION

The drop in blade size and the concomitant definition of the stem, coupled with decreasing stem size, also reflect sweeping changes in the character of the prehistoric projectile system. This observation applies not only to the shouldered and corner-removed point forms but also to the corner-notched types. It may be stretching our data somewhat to deduce the nature of the shaft of the projectile from point size and stem configuration and size, but it seems very likely that decreasing point size and the continual development of shoulders and separable stems indicate refinements in the use of the atlatl. These changes may be direct precursors to use of the bow and



KARTAR PHASE

13 = Cascade A
14 = Cascade B
15 = Cascade C
24 = Mahkin Shouldered
31 = Cold Springs Side-notched

HUDNUT PHASE

41 = Nespelem Bar
42 = Rabbit Island A
43 = Rabbit Island B
51 = Columbia Corner-notched A
52 = Quilomene Bar Corner-notched
61 = Quilomene Bar Basal-notched A
62 = Quilomene Bar Basal-notched B

COYOTE CREEK PHASE

32 = Plateau Side-notched
53 = Columbia Corner-notched B
54 = Wallula Rectangular Stemmed
63 = Columbia Stemmed A
64 = Columbia Stemmed B
65 = Columbia Stemmed C

Figure 11-13. Type groups plotted on axes of neck width and weight.

arrow (Corliss 1972; Thomas 1978). The bow and arrow itself probably did not enter the archaeological record until sometime after 2000 B.P., but there is every indication that dart shafts were becoming increasingly smaller during at least the preceding 4,500-4,000 years.

Decreasing stem size, and inferentially, decreasing projectile shaft size, are strongly correlated with decreasing effort expended in the manufacture and finishing of projectile points. Point types after c. 4000 B.P. generally show far less concern with uniform or careful manufacture, reflected in irregular flaking patterns, irregular cross-sections, and assymetrical outlines (Table 11-11 and 11-12). Also, these later point types show less wear and fewer associated wear patterns. It seems very likely that in the Kartar Phase, projectile points were multi-purpose, generalized penetrating, cutting, and scraping tools, and given their careful manufacture, and thickness, were less subject to loss and breakage. This latter assumption is also borne out by much lower frequencies of point fragments in the archaeological deposits. Throughout the Hudnut Phase and the later Coyote Creek Phase, however, points appear to have been used more specifically as projectiles, showing far less wear and fewer patterns of wear. Fragments of points also are more common, evincing both more frequent manufacture and intensive use as projectiles. One can argue on this basis that refinements were taking place that emphasized specialized projectile points, longer-distance kills, easily modifiable, reusable darts, and use of quickly made, less expensive point forms. A premium was established on lighter and more easily fabricated projectile equipment, innovations that were to lead directly to adoption of the bow and arrow.

To follow this line of reasoning further, the Rabbit Island Stemmed Type B, a smaller variant of Rabbit Island Stemmed A, and Columbia Corner-notched B, a scaled-down version of Columbia Corner-notched A, both occur well into the Coyote Creek Phase, post-2000 B.P., when we can assume that the bow and arrow was in use in the study area. Apparently the earlier dart point types were simply reduced in size and used to tip arrow shafts in the later period. It is no great leap then, to suppose that the process of projectile refinement went on for at least the last 6500 years.

Figure 11-13 shows the distribution of type groups plotted on axes of neck width and specimen weight. As shown, there is probably a linear relationship between decreasing neck width and projectile weight, and also, a very clear separation between those points that were most likely arrow point (Types 32, 53, 54, 63, 64, and 65) and those that were arguably dart point (Types 13, 14, 15, 24, and 31). Between these two extremes of the distribution are the point types that probably represent the gradual transformation of the projectile point assemblage (Types 41, 42, 43, 51, 52, 61, and 62). Table 11-14 lists mean neck width, basal length to total length ratios, and nece width to basal width ratios, for each type group, arranged from smallest to largest. Not surprisingly, there are rough correlations between decreasing neck width and decreasing basal length to total length ratios and the temporal distribution of type groups. The ranking of neck width to basal width ratios, however, is more complex, and probably represents little more than distinctions between lanceolate, shouldered lanceolate,

Table 11-14. Selected metric attributes for established projectile point types.

Point Type	Minimum Neck Width (.1 mm)	Point Type	Blade Length/ Total Length	Point Type	Neck Width/ Basal Width
54	28.82	12	0.60	15	0.13
32	28.43	14	0.60	13	0.25
65	28.43	32[1]	0.60	43[1]	0.34
53	28.96	13	0.62	14	0.49
63	34.06	15	0.62	12	0.56
64	34.45	24	0.65	41	0.61
43	42.34	31	0.65	24	0.63
42	48.16	51	0.71	42	0.63
51	51.50	41	0.75	64	0.91
41	55.63	53	0.77	63	0.98
31	55.90	52	0.78	54	1.03
62[1]	56.00	42	0.79	61	1.06
61[1]	56.17	43	.80	65	1.11
52[1]	63.60	54[1]	0.80	52	1.17
15	64.62	62	0.80	51	1.18
24	69.91	61	0.90	62	1.26
14	73.94	65	0.91	53	1.37
12	76.14	64	0.96	31	1.63
13	82.67	65	0.97	32	2.10

[1] Point type group is ranked by measurement category out of temporal order.

shouldered triangular, and side-notched projectile point forms, and thus, the general trend from lanceolate to triangular over time, with the maintained popularity of the side-notched form.

To assess these trends in point size and proportion we used Thomas' (1978) discriminant classification of dart points versus arrow points. Applying his classification functions, we grouped our point types into either dart or arrow point categories. Over 94% of all points were classified as dart points. This is surely in error, given that over 15% of all points in the collection are small-side-notched and delicate elongate barbed forms post-dating 1000 B.P., and commonly assumed to be arrow points. Possibly biases in the data (e.g., the points were from a limited number of geographic sources in California, the Southwest, and Eastern North America and all were in the American Museum of Natural History collections), invalidate its application to the Columbia Plateau. However, it also is possible that the continual process of refinement in point configuration and size on the Columbia Plateau has resulted in creation of somewhat larger projectile points for use with the bow and arrow than is common elsewhere in the United States.

CONCLUSIONS

Our analysis indicates that the finest temporal indicators are formal attributes and not technological attributes. There are, of course, technological differences: prior to 4000 B.P., points are made on blades as well as flakes; the earliest forms show little thinning of haft elements, evidence intense basal grinding, and show marked retouch. All of these characteristics are progressively rarer after c. 4000 B.P. Early points tend to show more wear and overlapping or contiguous patterns of wear, indicative of multiple uses. It is of interest that lanceolate forms after 4000 B.P., which may be knives rather than projectile points, show intensive wear characteristic of the earlier point types.

Distributions of mean neck widths, coupled with thicknesses of haft elements clearly suggest introduction of a different technology, probably associated with the adoption of the bow and arrow at or just prior to c. 2000 B.P. Further, several later projectile point types (Quilomene Bar Corner-notched and Quilomene Bar Basal-notched) show neck width distributions in the middle of the range noted for earlier types. This may indicate continued use of the atlatl well into comparatively recent time. The nature of the associated breakage patterns for these types also closely parallels that observed in earlier point types assumed to be atlatl points.

Despite the general concurrence of projectile point type temporal ranges in the Rufus Woods Lake project area and the Columbia Plateau as a whole, there are some specific differences. For instance, there is a discernible trend for types to have a longer temporal span on the upper Columbia River than on the lower Columbia River. Cold Springs Side-notched points, dated to c. 6500-4500 B.P. on the Snake River and lower Columbia River, are found from c. 5000-3500 B.P. in the Rufus Woods Lake Reservoir. Cascade points also continue in use in later periods in our study area. This difference may be more apparent than real, however, since these types also continue later in time along the Snake River drainage in nearby Idaho. A still more concrete discontinuity is present in the spatial distribution of later projectile point types. Examples of the Columbia Stemmed Series, well-dated and plentiful in sites on the lower Columbia River, are relatively rare on the upper Columbia River, and when present, occur with high frequencies of Plateau Side-notched points. Lesser numbers of Columbia Stemmed points, coupled with correspondingly higher numbers of Plateau Side-notched points, may indicate greater influence from the Plains culture area on the upper reaches of the Columbia than on the lower reaches of the drainage.

A tentative conclusion is that there is a greater correspondence between point types and type series on the Columbia Plateau and those defined for the Great Basin than has been recognized. In fact, many of the types defined for the Plateau can easily be subsumed under types defined for the Great Basin, and these have virtually identical temporal ranges (cf. Hester 1973; Heizer and Hester 1978; Holmer 1978; Thomas 1981). The Cold Springs Side-notched type is known from both areas. The Columbia Corner-notched variants equate with the Elko Corner-notched Series; the Mahkin Shouldered, Nespelem Bar and Rabbit Island Stemmed Types are very similar to the Pinto Series and the Gypsum point; and the Columbia Stemmed Series is virtually identical to the Eastgate/Rose Spring Series; The variants of Plateau and Desert Side-notched in both areas are quite similar, with the possible exception of more classic Plains types (eg. Avonlea) in the northern Columbia River drainage.

By applying a paradigmatic classification/attribute analysis and multivariate statistical routine to a large, well-dated collection of projectile points we have shown considerable success in defining recognized historical types and demonstrated potential to attain ever finer levels of classification aimed at identifying shifts in formal features or attributes over time. Descriptive types supply a check on the validity of recognized historical types, and offer more detailed information focusing on the distribution of attributes as well as specimens. Discriminant analysis has shown the autonomy of defined types, provided a usable metric definition of these forms, and perhaps best of all, offers a rapid means of classification that ensures comparability across a broad area.

What remains to be done is to further refine our typological analysis, explicitly comparing formal, technological, and functional variables on both a qualitative and quantitative level. Other study collections should be incorporated into and expanded analysis in an effort to construct a workable Plateau-wide sequence. We need to compare types defined for the Columbia Plateau with those recognized on the nearby northwestern Plains and in the Great Basin. And most importantly, our ultimate goal must be to assemble a practical summary document/handbook, for field and laboratory use, that outlines attributes of defined projectile point types. This would function as a key which would allow researchers to quickly field-assign a specimen, or a diagnostic part of a specimen, to a type series and then to a type, based upon the presence or absence of specified qualitative and quantitative attributes.

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12. SUMMARY OF FAUNAL DATA

by Stephanie Livingston

The faunal assemblages from 18 sites excavated in the salvage operations of the Chief Joseph Dam Archaeological Project yielded 25,060 elements that were identifiable to at least the family level. An additional 13,535 mammalian elements were identified to size categories: elk size (cow, bison, elk, horse) or deer size (deer, mountain sheep, antelope). The resulting identified assemblage thus includes over 38,000 elements. The total identified assemblage is 84.4% mammals, representing at least 33 species in 20 families; 4.2% reptiles; 1.5% amphibians; and 9.9% fish. A small number of bird bones remain to be identified. The fish and herpetofauna are summarized in the descriptive summary of this report, but the remainder of the report is primarily concerned with the mammalian remains.

The cultural assemblages from these 18 sites were recovered from 84 analytic zones which have been assigned to three phases based on radiocarbon dates and stylistic analysis of projectile points. Coyote Creek Phase (2000-50 B.P.) deposits contributed 27.3% (10,186 elements) of the identified faunal elements, Hudnut Phase (4000-2000 B.P.) deposits 47.8% (17,850 elements), Kartar Phase (7000-4000 B.P.) deposits 18.9% (7052 elements). The remaining 5.9% (2219) could not be assigned to a single phase. Individual site assemblages are described and discussed separately in the site report series.

This summary is presented in two parts. The first is a descriptive summary of the total assemblage by taxon. This section gives a synoptic view of the total assemblage and some basic background information used in drawing conclusions from the faunal data. The second part presents selected aspects of the faunal analysis pertinent to the inferences and conclusions drawn from the faunal remains as they pertain to the archaeology of the Chief Joseph project area.

DESCRIPTIVE SUMMARY

Table D-6, Appendix D presents the number of identified specimens per taxon by analytic zone for all sites included in this report. The following is an account of taxa identified with a brief description of aspects of the natural and cultural history of each taxon where it is relevant to the synthetic discussion that constitutes the remainder of this report.

In this report all counts of faunal remains are given as NISP (number of identified specimens). Both NISP and MNI (minimum number of individuals) were given in the individual site reports. The space necessary to present both for the entire data set and the resultant complexity of the tables and text prohibit presenting both here. The implications of choosing one measure of quantification over the other for this data set are discussed below.

CLASS PISCES

Family Cyprinidae NISP=807
Family Catostomidae NISP=826
Family Salmonidae NISP=3237

Onchorhynchus tshawytscha NISP=101

Most fish specimens in these assemblages are vertebrae. All fish vertebrae with parallel-sided fenestrated centra were identified as salmonid. Identification of non-salmonid fish vertebrae to family was made on the basis of size. We recognize that this system of identification of non-salmonid fish is not robust and advise caution in interpretation of these specimens. Only otoliths, which were found in only four sites (45-DO-285, 45-DO-326, 45-OK-211, and 45-OK-250) were identified to species. Inadequate comparative collections precluded more specific identification of fish remains or identification of elements other than vertebrae and otoliths.

CLASS AMPHIBIA

Family Ranidae/Bufonidae NISP=344

Both frogs and toads live in the project area (Stebbins 1966). Lack of comparative material precluded identifying these specimens to even the family level. In many cases, the specimens appear to have been intrusive; they are less discolored than other bone specimens from the same deposits and include representatives of most major skeletal parts. However, in some assemblages the frequency of lower limb elements and parts of the innominate suggest other than natural deposition.

CLASS REPTILIA

Chrysemys cf. *picta* NISP=1349

All turtle specimens identified are carapace or plastron fragments. These specimens are distinctly turtle, but the fragmentary condition of all turtle elements and the lack of comparative materials precluded firm species level identification.

C. picta is the only native turtle now living in the project area. Although Ray (1932:87) reports the western pond turtle (*Clemmys marmorata*) in the eastern part of the state, these turtles are only known to occur on the west side of the Cascade Mountains (Stebbins 1966). There is no way to verify

Ray's identifications, and in the absence of evidence of the occurrence of species of turtles other than C. picta, the most likely species represented by the archaeological specimens is C. picta. Consequently, all turtle specimens were tentatively referred to that species.

Family Colubridae NISP=789
Family Viperidae NISP= 5

Snake vertebrae were identified to the family level on the basis of size. We did not have adequate comparative materials to make further identifications. Most snake elements appear to be intrusive; they are generally unbroken and less stained than other bone materials occurring in the same deposits, and they were generally recovered in clusters of many vertebrae of the same size suggesting discrete individuals.

CLASS MAMMALIA

Order Insectivora
Family Soricidae

Sorex spp. NISP = 4

At least four species of shrews live in the project area today: Sorex monticola, the dusky shrew; S. vagrans, the vagrant shrew; S. cinereus, the masked shrew; and S. merriami, Merriam's shrew. While nearly all shrews inhabit damp, moist places; of these four, the Merriam's shrew may be found under quite arid conditions (Ingles 1968). It was not possible to determine the species of any of the shrew elements recovered in these assemblages, but little effort was expended in the attempt. Because shrews are so small, recovery of shrew elements, even with 1/8 inch screen, is very fortuitous. Consequently, little information would be gained by pursuing more precise identification of the few elements in this assemblage at this time.

Order Lagomorpha
Family Leporidae

Lepus cf. townsendii NISP = 35
Sylvilagus cf. nuttallii NISP = 20

Lagomorphs were found in only 21 of the 84 assemblages. They are relatively abundant only in the Kartar component at 45-OK-11 where they account for little more than 1% of the small mammals. Hares were identified in very low frequencies from both sides of the river in all phases. Cottontails were found almost exclusively on the south side of the river, but also in all three phases.

There are currently 3 species of hares living in or near the project area: Lepus townsendii (white-tailed hare), L. californicus (black-tailed hare) and L. americanus (snowshoe hare). Black-tailed hares are recent immigrants into the Columbia Plateau (Couch 1927). Snowshoe hares inhabit higher elevation wooded areas and are not known to live in the Columbia Plateau (Ingles 1965:139; Dalquest 1948:382). The most likely hare to have inhabited the project area prehistorically is the white-tailed hare. It was generally not possible to obtain secure species level identifications for leporid elements on morphological criteria. Most elements were identified as Lepus cf. townsendii as the hare most likely to be represented based on historic distribution data.

Early explorers and settlers found abundant white-tailed hares in eastern Washington (Taylor and Shaw 1929), but recent wildlife surveys of the area indicate that lagomorphs are surprisingly rare (Erickson et al. 1977:237, Payne et al. 1975). No explanation is offered for low lagomorph densities other than the general statement that low furbearer population densities along the Columbia River correlates with the sparse riparian development of the area and probably is influenced by it (Payne et al. 1975:158). The low density of white-tailed hares in eastern Washington has been attributed to the historic invasion and spread of the black-tailed hare and reduction of native bunchgrass by overgrazing (Dalquest 1948:381). However, black-tailed hares have only expanded their range as far north as the Columbia River(Ingles 1965), and even the black-tail is not abundant in the project area. If hares were being introduced into the archaeological sites in proportion to their availability in the surrounding area, their low densities in these assemblages suggest that the conditions resulting in low hare densities today prevailed in the past.

Sylvilagus nuttallii, Nuttall's cottontail, is the most likely species of of rabbit to be found in project area sites. S. floridanus, the Florida cottontail, and S. idahoensis, the pygmy cottontail, also currently inhabit parts of eastern Washington. Florida cottontails were recently introduced and pygmy rabbits are only found far to the south of the project area. Consequently, although many of the rabbit elements could not be identified to the species level on morphological criteria, they are assigned to S. cf. nuttallii on the basis of biogeographical probability. Recent wildlife surveys indicate that where cottontails are found today they are common, but their distribution appears to be patchy.

As with the hares, if cottontails were being used prehistorically in proportion to the abundance with which they occurred in the local environment, the low frequency of cottontail remains in the archaeological assemblages may reflect relatively small populations of cottontails in the area prehistorically. The fact that a species which occurs in such low frequencies was almost exclusively found in sites on the south side of the river cannot support a detailed paleoenvironmental inference due to the behavior of rare taxa in any quantitative treatment of faunal assemblages (see Grayson 1979).

Hares and rabbits were at least occasionally used by site occupants. The relatively frequent occurrence of burned bone demonstrates that at least some, and probably most, of the lagomorphs were deposited in some manner by people. Yet the low frequency of lagomorph remains indicates that rabbits and hares were not a major components of subsistence activities represented in these assemblages. The low frequencies of lagomorph remains are probably not primarily a function of preservation or recovery factors selecting against the small, fragile remains, given the frequent recovery of fish and other small, fragile bone fragments.

Order Rodentia

Family Sciuridae

Marmota flaviventris NISP = 791

Marmots are generally found near permanent water sources, but wander extensively. Their primary requirement is the presence of rocks; they especially favor basalt talus (Dalquest 1948, Ingles 1965), a common habitat near many of the sites. Although marmots are common residents near most of the excavated sites, they hibernate or estivate for most of the year. They are active and available for capture only during the spring and possibly a short time during the fall of each year. At least 2% of all recovered marmot elements are burned, suggesting that marmots were at least occasionally used by people. If marmots were captured and used by prehistoric site occupants only during the time of year they are currently active, marmots would be expected to represent only a minor contribution to the total annual faunal resources represented in any site.

Small numbers of marmot elements were found in deposits of all ages throughout the project area. With the exception of 45-OK-11, marmot elements represent a minor component of each site's faunal assemblage. The Kartar Phase assemblage at 45-OK-11 contains the largest absolute number (NISP = 255) of marmot elements of any component in the project. The total faunal assemblage, however, is quite large (NISP = 6691) and constitutes most of the Kartar Phase fauna for the entire project area. However, marmots are also relatively abundant at 45-OK-11, accounting for over 22% of the small mammals in the Kartar component and over 25% of the small mammals in the Hudnut component.

Aside from their high relative abundance, their are two intriguing aspects of the marmot remains at 45-OK-11. Although most major body parts are represented, there is an unusually high proportion of astragali. A large number of marmot elements, including many astragali, are concentrated in Upper Housepit 1, a Kartar Phase house. The astragali were apparently deliberately removed from the rest of the carcass, resulting in these elements being deposited separately and in unexpectedly high frequencies compared to other skeletal elements. None of the astragali, however, bear any visible marks suggesting the motives or techniques used for their accumulation.

Spermophilus spp. NISP = 81
Spermophilus washingtoni NISP = 27

Two species of ground squirrel currently live in or near the project area: *Spermophilus washingtoni*, the Washington ground squirrel, which inhabits the grassland and low sage south of the Columbia River; and *S. columbianus*, the larger Columbia ground squirrel, in the more humid higher elevation grasslands and wooded habitats throughout eastern Washington. S. townsendii, the Townsend ground squirrel, currently lives in the sage grassland of the central Columbia Basin south of the project area.

All ground squirrel elements recovered fall within the size range of S. washingtoni and S. townsendii; none were large enough to indicate the presence of S. columbianus. Of the 100 elements recovered only 27 could be identified to the species level. These 27 elements include 26 mandibles and one skull, all of which retained the molariform teeth. The mandibular molars of the archaeological specimens are relatively square in general outline, and the P_4s are subequal or only slightly smaller than the M_1s. These characters compare well with S. washingtoni, but the P_4 of S. townsendii is noticably smaller than M_1, and all molars are more trapezoidal in general outline. The skull of S. washingtoni is narrower in relation to its width than S. townsendii. We have accepted these identifications as they make biogeographical sense, but note that the series of reference specimens used is very small.

All specimens identified as S. washingtoni were recovered from 45-DO-214. Only 5 of the remaining Spermophilus sp. elements are from Okanogan County sites (45-OK-4, 45-OK-250). This distribution of elements may reflect capture of Washington ground squirrels on the south side of the river where they are currently the resident ground squirrel. The few cases of ground squirrel elements in sites on the north side of the river may reflect transport of Washington ground squirrels captured on the south side of the river across to Okanogan sites, or presence of the higher elevation dwelling Columbia ground squirrel. In either case, the more abundant ground squirrel remains in Douglas County sites and the relatively rare remains in Okanogan County sites probably reflects human use of ground squirrels in relation to their availability in proximity to the sites.

Family Geomyidae

Thomomys talpoides NISP = 2575

Only one species of pocket gopher, Thomomys talpoides (northern pocket gopher), lives in eastern Washington. Gopher elements are common in most eastern Washington archaeological faunas (cf. Lyman and Livingston 1983), and the Chief Joseph assemblages are no exception. Gophers usually have a relatively narrow range of tolerance in regard to environmental adaptations. They prefer deep soil along streams and in meadows, but they occasionally live in rocky soils on dry slopes. Their major requirement appears to be sediments that are deep enough for digging burrows (Dalquest 1948, Ingles 1965). They also tend to have a rather small home range, restricted for the most part to the extent of the elaborate burrow system excavated by the individual gopher. These burrow systems may be up to five feet deep.

Although abundant in the archaeological assemblages and fairly restricted in habitat preference, gopher remains tell us more about one source of site disturbance than about past environmental conditions. Most fossorial rodents, including pocket gophers, appear to find the sediment disturbance caused by human occupation an improvement to their environment. The predilection of fossorial rodents to dig in culturally disturbed deposits is only too obvious as excavators attempt to trace housepit floors and feature boundaries which are paralleled and crosscut by extensive burrow systems.

Family Heteromyidae

Perognathus parvus NISP = 996

The Great Basin pocket mouse (_Perognathus parvus_), the single heteromyid rodent living this far north in the Columbia Basin, is, like pocket gophers, abundant in al' eastern Washington archaeological faunal assemblages. Their abundance in the sites may be attributed primarily to their extensive burrowing activity. Pocket mice tend to live in drier habitat types than pocket gophers, generally placing their burrows under sage in friable soil (Ingles 1965:213). It is not uncommon, however, to find both pocket mice and gophers in the same area. Pocket mice tend to burrow no more than 2 feet deep. Again, as with the gophers, the abundant evidence of pocket mice may reveal more about site disturbance than past environmental conditions or cultural activity.

Family Castoridae

Castor canadensis NISP = 36

Although beaver have been introduced in many places along the Columbia River (Ingles 1965:242), the occurrence of beaver elements in these prehistoric sites indicates that beaver is more likely a native inhabitant of a variety of riverine habitats in Washington (Dalquest 1948). Their primary requirements appear to be willow or aspen and permanent fresh water. There is ethnographic evidence that beavers were regularly sought (Post 1938), presumably for their pelts and as a food resource, although neither is explicitly stated. Beaver teeth are known to have been used by the Coeur d'Alene to incise wood, bone, antler, and soft stone (Teit 1930). The fact that many of the beaver elements recovered are incisors may indicate that they were being used in a similar manner by the prehistoric inhabitants of the project area. On the other hand, because teeth tend to preserve better than bone, preservation factors alone may be responsible for the low frequency and element representation of beavers.

Family Cricetidae

Peromyscus maniculatus NISP = 124

Deer mice are found in nearly all communities and life zones throughout the state, and often greatly outnumber all other rodents in the area (Ingles 1965:257). The small mammal survey conducted in the project area in 1974 and 1975 in fact found the most abundant species captured to be _P. maniculatus_

(Erickson et al. 1977:238). Deer mice usually nest above ground in logs and rocks, but they sometimes use shallow burrows. The small number of deer mice found in these assemblages may be because their surface dwelling habits generally prevent them from being buried quickly enough to be preserved.

Neotoma _cinerea_ NISP = 10

Bushy-tailed wood rats are found in most environments throughout the state. The small mammal survey conducted in 1974 and 1975 found bushy-tailed woodrats in coniferous forest, macrophyllous vine and shrub, and in rocky habitats in the project area (Erickson et al. 1977:241). Currently they are not abundant in the project area, and may not have been in the past. However, they do not appear to prefer the riparian habitat that most likely surrounded most of the sites when they were occupied, and there is no evidence indicating they were sought by prehistoric people. Even if they were abundant in the nearby talus or woodland there is no reason to expect them to be well represented in the site deposits.

Microtus sp. NISP = 84

Three species of _Microtus_ live in the site area: _M. montanus_, _M. pennsylvanicus_, and _M. longicaudus_. All three prefer marshy habitats and/or live near streams. _M. montanus_ can also be found in more xeric areas. All three species are primarily surface dwellers. They tend to use runways rather than burrows, and will build their nests on the surface in the winter. When they do burrow, or build subterranean nests, they usually stay in the upper ten inches of sediment (Maser and Storm 1970). We were unable to determine the species of any of the elements identified as _Microtus_.

Lagurus _curtatus_ NISP = 166

Sagebrush voles generally inhabit dry sagebrush areas with little grass. Their burrows tend to be shallow (4-6 inches), with nests about 7-10 inches in diameter (Maser and Storm 1970:142). They are currently found only above 1000 feet in elevation, are active year round, and do not store much food (Johnson et al. 1948). The excavated sites range in elevation from 950 feet to 1000 feet, at the boundary of the current range of the species. Sagebrush voles were found in assemblages from 14 of the 18 sites. Only skulls and mandibles could be distinguished from _Microtus_. _Lagurus_ has distinctive molars, and the edentulous mandibles can be distinguished by the location of the mandibular foramen (Grayson 1983).

Ondatra _zibethica_ NISP = 20

Muskrats are residents of lower elevation cattail marshes, ponds and the banks of slow moving streams throughout the state. Seldom far from permanent water, muskrats live in banks, in burrows with the entrances underwater. Although muskrats are active year round, the waterproof pelt is at its prime during the winter months. The ethnographic literature indicates that muskrats were sought for their pelts (Ray 1932) but their no indication that the meat of this animal was eaten, although it is considered edible in other parts of the country (Ingles 1965:294). None of the archaeological elements showed evidence of use.

Family Erethizontidae

Erethizon dorsatum NISP = 78

Porcupines are common residents in the Rufus Woods Lake area and are generally associated with ponderosa pine within coniferous woodlands over a shrub layer habitat type (Erickson et al. 1977:174). However, porcupines have been recorded in shrub steppe, *Equisetum*, grassland, cobble, shoreline gravel and sand dunes along the Columbia River indicating the species has a broad range in the project area (Payne et al. 1975:214).

All the porcupine elements were recovered from the north side of the river; most (68 elements) are from the Kartar Phase component at 45-OK-11. The elements recovered from the archaeological deposits may represent animals that were introduced into the sites as a result of use by people. According to the ethnographic records porcupines were eaten, although not favored, and their quills were used for ornaments (Post and Commons 1938:45, Ray 1932). However, the low overall density of porcupine elements suggests that either this taxon was used in a manner that did not result in the osseous remains being discarded in the site area, or that the porcupine elements were introduced by predators or scavengers. The cosmopolitan nature of current porcupine populations in the project area precludes inferring cultural deposition on the basis of habitat preference.

Order Carnivora

Family Canidae

C. spp. NISP = 192
Canis latrans NISP = 6
C. lupus NISP = 7
C. familiaris NISP = 121
Vulpes vulpes NISP = 6

Canis latrans, coyote, is currently the most common and economically significant predator in the project area. *C. familiaris*, domestic dog, is common in the project area today, and has been recorded in archaeological assemblages from the northwestern U.S. for the last 10,000 years (Lawrence 1968). *C. lupus*, wolf, although now extinct in the state of Washington, is known to have been a resident of the area in the past (Dalquest 1948).

Most of the individual canid remains recovered from these sites could not be identified to the species level. Elements identified as *C. lupus* were generally assigned to that species on the basis of extremely large size. Elements identified as *C. familiaris* were assigned to that species on the basis of dental crowding and molar morphology (Krantz 1959, Olsen and Olsen 1977). The 110 elements identified as *C. familiaris* in the Hudnut component at 45-OK-258 represent a single articulated individual identified as domestic dog on the basis of dental morphology. The individual appeared to have been deliberately buried. Fish bone found in the abdominal cavity suggests that the dog had fish as a last meal. All elements identified as *Canis* sp. fall within the size range of *C. latrans* and *C. familiaris*.

An argument as to the species identity of the elements identified as Canis spp. cannot be made on the basis of likelihood of representation. Domestic dogs have great antiquity in the Pacific Northwest and could occur in cultural assemblages of any age. Coyotes, which are cosmopolitan and more abundant than most carnivores, being closer to an omnivorous scavenger in habits and population densities, are equally likely to occur. It would be interesting to ascertain the species, however, because dogs and coyotes have very different implications for human activities. Dogs were used ethnographically for hunting deer, but were not eaten except in emergencies (Post 1938). Coyotes, however, were considered good food (Ray 1932:90). There are a number of burned canid elements in these assemblages, indicating another, very different means of disposing of canid carcasses than the articulated dog skeleton mentioned above. Whether the difference in disposal pattern represents a distict treatment of different canid species or a change in attitude toward a single species over time is impossible to determine from the present evidence. The single articulated skeleton was the only indication of preferential treatment of any of the canids.

Family Ursidae

Ursus spp. NISP = 4
Ursus americanus NISP = 5
Ursus arctos NISP = 1

Both black bears (*Ursus americanus*) and grizzly bears (*U. arctos*) are native to Washington state. Black bears occur in greatest abundance in the forested uplands (Dalquest 1948:172), but are known to frequent the banks of the Columbia River during berry season (Ray 1932:82). Periodic signs of black bears were found along the Nespelem River during a twelve month survey in 1974-1975. They were thought to be transient animals whose primary residence was away from the reservoir (Erickson et al. 1977:233). Many current local residents report bear sitings near the river during huckleberry season, and a brown phase specimen was photographed at the mouth of the Nespelem River (Salo, personal communication). Grizzly bears, now extinct throughout the state, apparently never enjoyed as wide a distribution as the black bear (Dalquest 1948). There is, however, no reason that grizzly bear should not be found in these assemblages. Although the size ranges of the two species of bear do overlap, grizzly bears are generally much larger (Lyman, in press). There is little question that a metapodial from 45-OK-11 is grizzly bear due to its extremely large size. There are ethnographic records for hunting of both species (Ray 1932: Post 1938). The small number of identified specimens makes it difficult to discern if these animals were deposited by people or by natural mechanisms.

Family Mustelidae

Martes americana NISP = 11
Martes pennanti NISP = 7

Pine martens (Martes americana) inhabit dense coniferous forests and high elevation rockslides (Dalquest 1948, Ingles 1965). Fishers live in the upland forests of northern North America, and their ranges extend south along the major mountain ranges (Hagmeier 1956, Kurten and Anderson 1980:148; Hall and Kelson 1956:901). In Washington, fishers occupy upland habitats somewhat lower in elevation than martens (Dalquest 1948:188, Ingles 1965:371). It is possible that fishers once lived in the site area when the riparian vegetation was better developed. In the eastern states they are known to live in low wet areas and along the banks of streams (Hagmeier 1956:151). Because fishers are solitary animals that require large territories their populations are never large in any living fauna. Fishers spend much time in the trees, as well as on the ground, feeding on rodents, including porcupines.

The small population size and forest habitat preference of both martens and fishers reduce their chances of becoming part of any preserved faunal assemblage. Consequently elements of prehistoric Martes are always rare (Anderson 1970:4). Indeed, they are rare in these assemblages, marten being identified only in the three largest faunal assemblages and fisher only in the largest. However, recent reports of fisher remains in the Appalachians, Midwest and southern states indicate that fishers may have been more widely distributed in the past (Anderson 1984:257; Kurten and Anderson 1980:148). The extinct noble marten (Martes nobilis) has recently been found in a number of sites in the western states (Grayson 1984), and the pine marten has been recorded in several western sites (eg. Ziegler 1965), but there are very few reports of any members of the marten family from anywhere in the Columbia Basin (see Gustafson 1972 for a major exception). Although M. pennanti still lives in very small numbers in the uplands near the project area, the fisher remains from 45-OK-258 represent only the second prehistoric record for fisher in eastern Washington (Osborne et al. 1952).

The ecological meaning of these specimens is unknown because of the probable intervention of people in their deposition. Although not currently natives in the immediate vicinity of the archaeological sites, there is no reason to infer range shifts to account for the presence of either of these valuable furbearers in project assemblages. The ethnographic literature reports that martens and fisher were routinely trapped for fur in the adjacent uplands (Ray 1932:85). Given the paucity of corroborative evidence for environmental or other change allowing for proper environment for martens or fisher in the area, it is more likely they were introduced into these lower elevation sites by people who hunted in the adjacent uplands than that there has been a range change for either taxon. The fisher was found in the 45-OK-258 assemblage, which contained several carnivorous furbearers; pine marten, long-tailed weasel (*Mustela frenata*), badger (*Taxidea taxus*), and cougar (*Felis concolor*). Of all the mustelid remains only a single fisher element shows evidence of butchering; there are cut marks around the neck of the femur.

Mustela frenata NISP = 9

The long-tailed weasel has the widest distribution of any American weasel. They may be found in all habitats except true deserts. Weasels are ubiquitious in Washington. They are active predators known to follow prey species such as pocket gophers into their burrows.

Taxidea taxus NISP = 63

The badger is a powerful burrower found throughout eastern Washington, although not in large numbers (Ingles 1965). Badgers were trapped regularly by the Sanpoil and Nespelem (Ray 1932:85). Their solitary and nocturnal nature and their habit of digging deep holes in friable soil would make the badger a difficult animal to capture, but a likely animal to become naturally incorporated into deposits in the floodplain zone. In some sites at least, it appears that badgers may be present due to both natural occurrence and cultural use. At 45-DO-326 a cluster of 52 elements, apparently a single animal that may have died in its burrow, were found in one part of the site. None of these elements were burned or showed evidence of butchering, yet a badger element was found in another area of the same site was burned, suggesting humans may have deposited it.

Mephitis mephitis NISP = 10

Striped skunks are common in streamside thickets throughout the project area. As with the porcupine, there was no taboo among local Native Americans against eating skunk, but skunk was not popular in the diet (Ray 1932:90). There is no evidence that any of these elements were introduced into these assemblages by cultural agents of deposition.

Lutra canadensis NISP = 7

The current range of the river otter is along rivers, marshes and lakes throughout Washington state excluding the central Columbia Basin. However, they were not recorded in either of two wildlife surveys conducted in the riparian habitats in the project area during the 1970's (Payne et al. 1976, Erickson et al. 1977). All river otter elements are from the Coyote Creek assemblage at 45-OK-2.

Family Felidae

Felis concolor (NISP = 4)

Although this report otherwise considers only the fauna from the salvage excavations, there are four specimens from testing at 45-OK-258 that deserve mention. These four specimens (3 phalanges and a distal metapodial) are the first reported specimens identified as cougar from a prehistoric context in eastern Washington. The testing unit in which they were found has not been tied into the salvage components so the age of the specimens is not known. The identification of cougar at 45-OK-258 adds yet another species to the unusually diverse carnivore assemblage at that site.

Lynx rufus NISP = 9

Bobcats (_Lynx rufus_) are ubiquitous in Washington, while Canadian lynx (_L. canadensis_) are less common and inhabit the forested regions in the higher mountains (Ingles 1965). Bobcat and Canadian lynx may be difficult to distinguish osteologically. Postcranially, the major difference between the species is size; the bobcat is somewhat smaller. Small felid elements were identified as _L. rufus_ on the basis of modern distribution and size, but it is recognized that _L. canadensis_ could also be represented. The presence of two butchered elements at 45-OK-11 indicate that _Lynx_ was sought at least occasionally by people, but the small number of bobcat elements from the entire project indicates this species probably did not represent a major resource to prehistoric populations.

Order Perissodactyla

Family Equidae

Equus caballus NISP = 27

Horses apparently spread onto the Columbia Plateau from the Shoshone of southern Idaho during the early 18th century (Wissler 1914; Haines 1938). Although there is no indication that horses were eaten, they were used for hunting, transportation and trade (Anastasio 1972:127-130). The impact of the introduction of horses into Plateau cultures is still a subject of controversy (Anastasio 1972; Ray 1932; Winans, in Ross 1871; Grabert 1970; Mierendorf et al. 1981; Schalk 1982).

These elements represent the remains of two horses, one in the latest component at 45-OK-2, and one in the latest assemblage at 45-OK-258 which also contains the remains of domestic dog.

Order Artiodactyla

Family Cervidae

Cervus elaphus NISP = 114

Canadian elk are currently restricted to the Canadian and Transition life zones of the Cascades far south and west of the project area (Ingles 1965:419) Almost extinct in the state by the turn of the century, elk were actively reintroduced during the early decades of the 20th century (Couch 1935).

Elk are not uncommon in archaeological faunal assemblages in eastern Washington, even in the most arid parts of the Columbia Basin (Lyman and Livingston 1983). Gustafson (1972) has argued that the relative representation of various skeletal elements in sites in arid settings suggests that this large animal probably was not transported for any great distance. The small number of elk elements distributed across a number of subassemblages does not allow evaluation of this assertion as it applies to the Chief Joseph Project record. On the other hand, the regularity with which elk elements were recovered suggests these animals were at least occasionally hunted.

Odocoileus spp. NISP = 9685
Odocoileus hemionus NISP=21
Odocoileus virginianus NISP=31

The most frequently occurring artiodactyl in virtually all faunal assemblages considered here, as well as many other eastern Washington archaeological faunas, is deer (Odocoileus spp.). It has sometimes been assumed that the deer in eastern Washington archaeological assemblages are mule deer, O. hemionus (Osborne et al. 1952, Chance 1975). This assumption is based, in large part, on the knowledge that the most widespread deer in the Columbia Basin in historic times has been the mule deer. Generally, however, archaeological deer are identified only to genus.

Census data for mid-Columbia riparian habitats in 1975 show that mule deer range throughout the region. In the project area they occur in greatest numbers near the sites in the late-summer and fall. Census data also indicated that 88% of the mule deer observed were on the south side of the river (Erickson et al. 1977). White-tailed deer (O. virginianus) have been reported from both the Hanford Reservation and Rufus Woods Lake, but their main populations occur along Lake Roosevelt and northward (Payne et al. 1976:100). Currently they may not be year round residents of the project area. Erickson et al. (1977:174) list white-tailed deer as rare, local migrants to the riparian habitats of the project area. All white-tailed deer observed in their survey were seen during the winter. Apparently the animals migrated down Coyote Creek to escape snow accumulating in the highlands. Most observations of white-tailed deer were on the north side of the river; those seen on the south side of the river were thought to have crossed over. White-tailed deer also inhabit island refuges in the lower Columbia and it has been speculated that they may have once inhabited brushy river bottoms farther upstream (Taber 1979:73).

When white-tailed and mule deer ranges overlap, the white-tailed deer are generally found in the denser vegetation of river bottoms and at higher elevations. Mule deer generally prefer the more open, higher areas. All archaeological sites in this analysis are in river floodplains due to the restrictions of the project boundaries. However, the sites lie in what was probably riparian habitat at the time the sites were occupied, and within accessible distances of the forested uplands. Consequently, although most of the deer in the project area today are mule deer, when we began our analysis we considered it highly probable that at least some of the deer in the archaeological assemblages were white-tailed deer.

Unless the antlers or facial bones are recovered, it is difficult or impossible to distinguish between the osseous remains of the two species of deer. In only a few instances have the appropriate elements been recovered to allow determination of species for deer in archaeological collections from eastern Washington (Lyman 1976, Gustafson 1972). Because we were unable to determine the species of deer in these assemblages using standard morphological criteria, discriminant analysis was used to identify the species of deer mandibles in these assemblages. Mandibles were chosen for this analysis because they are elements that preserve well in archaeological deposits and because mandibular measurements have been demonstrated to give satisfactory results in determining the probable species of deer in other studies (Reese 1971). Discriminant functions were derived from measurements taken on the molariform teeth of 48 specimens of modern *O. hemionus* and 43 specimens of modern *O. virginianus* housed in various western states universities, museums and private collections. Because most archaeological specimens are fragmentary, measurements on various combinations of teeth were submitted to the BMDP discriminant analysis program. A set of functions were found to reliably identify specimens of known species to the correct species with posterior probabilities of at least 0.75. These functions were used to identify 52 mandibles, or fragments of mandibles, from the Chief Joseph assemblages to species. Table 12-1 lists the specimens identified to species by site.

Table 12-1. Deer mandibles identified to species using discriminant analysis.

Site	*Odocoileus hemionus* (NISP)	*Odocoileus virginianus* (NISP)
45-DO-242	3	5
45-OK-2	3	10
45-OK-4	6	2
45-OK-250	4	4
45-OK-258	3	6
45-OK-288	1	5

The sample of archaeological specimens indicates that white-tailed deer probably were taken by prehistoric people at least as frequently as mule deer during all time periods represented. This implies that either there has been a change in the range and/or abundance of white-tailed deer, there was a great deal of selective hunting, or most hunting was done during the winter when the relative abundance of white-tailed deer was greater.

Ethnographically, people would hunt as far away from their villages as they could walk in a three day period. Deer were often taken by driving them into the Columbia River. Both whole and partially butchered carcasses were carried to the village sites on the hunter's back. In either case, butchered or whole, the head of the animal was brought back (Post 1938). It must be considered, then, that these animals may represent a broader catchment area than the floodplain site environment. But it is unlikely that white-tailed deer were hunted at great distances while mule deer were readily available near the sites. There is no reason to expect utilization of one deer species to the exclusion of the other unless one species was much more accessible geographically or much easier to hunt. Larger game animals appear to have been utilized at most sites in proportion to their expected availability if the varying proportions of elk, bison, antelope, and mountain sheep in different sites may be interpreted as reflecting hunting practices similar to those recorded in the ethnographic literature (Post 1938, Ray 1932). If modern distributions of deer species are an adequate model of prehistoric distributions, then the expectation would be that most archaeological deer would be mule deer. The relative abundances of the two species as shown in Table 12-1 suggests that either white-tailed deer distribution was much different in the past, or deer hunting practices responsible for accumulating these elements were different than those described in the ethnographic literature.

Similar findings from archaeological excavations at Avey's Orchard near Wenatchee, Washington support the probability that the relatively high proportion of white-tailed deer in the Chief Joseph Project assemblages reflect a change in deer distribution rather than a change in cultural activities. As in the project area, there are riparian habitats in the canyon bottoms of the Wenatchee area appropriate for white-tailed deer, but a recent summary of wildlife associated with riparian habitats of the area reported only mule deer in the Wenatchee area (McKern 1976). Of the five deer elements from Avey's Orchard identified to species using the same technique of discriminant analysis, four are white-tailed deer (Lyman 1985:230-231).

Family Antilocapridae

Antilocapra americana NISP = 293

Although there are those who would still argue that the pronghorn antelope is not indigenous to the state of Washington, speculation regarding the extent of pronghorn range in the Columbia Plateau has long concerned mammalogists (Dalquest 1948, Bailey 1936) and archaeologists (Osborne 1953). It is difficult to ascertain the extent of pronghorn range at the time of

European contact from the accounts of early trappers and explorers because they often did not distinguish between pronghorn and deer; or they were not particularly looking for pronghorn, being more interested in the furbearing mammals; or they were rarely in the open plains habitat preferred by the pronghorn (Bailey 1936:71). It is apparent, however, from the numerous reported occurrences of pronghorn in archaeological deposits from along the Columbia River (Lyman and Livingston 1983) that pronghorn did, in fact, range over most of the open sagebrush areas at least to the Canadian border (Bailey 1936:71). The low abundance of pronghorn relative to deer in archaeological assemblages may reflect either the natural relative abundances of the two taxa in the area prehistorically, preferential hunting of artiodactyl taxa, or the relative intensity of use of different habitat types by people. If people were hunting in the areas surrounding the floodplain sites, it is reasonable to expect the most abundant taxon represented in the sites would be deer. Further, because many postcranial elements of pronghorn, mountain sheep and deer cannot be distinguished when they are extremely fragmented, pronghorn could occur in higher relative abundances than they appear due to the difficulty of identifying postcranial elements. Many antelope, sheep and deer elements could only be identified as small artiodactyl (deer-sized) because they are broken into extremely small pieces.

Family Bovidae

Bison bison NISP = 27

All bison currently living in the project area are introduced. Historic records indicate that bison once inhabited eastern Oregon south of the Blue Mountains in considerable abundance (Bailey 1936:57). They were thought to occasionally wander into the state of Washington (Dalquest 1948), but seeing them as far north as Grand Coulee was considered rare or unheard of (Gibbs 1860:138, Dalquest 1948, Taylor and Shaw 1929).

Prehistoric bison remains have previously been recovered from sites 45-OK-2, 45-OK-10, 45-OK-11, 45-OK-12 (Osborne et al. 1952) and 45-OK-5 (Osborne 1953) in Okanogan County and numerous sites to the south (Schroedl 1973, Lyman and Livingston 1983). Although dating many of the bison remains recovered by early researchers in eastern Washington is somewhat difficult, Schroedl (1973) has determined that bison were regularly utilized by Plateau cultures from 2500 B.P. until shortly before contact. His study indicates that bison populations began to decline about A.D. 1500 and were virtually extinct by the historic period. Bison were recorded in low frequencies in assemblages in all three Phases: Coyote Creek NISP=12 (45-DO-214), Hudnut NISP=15 (45-OK-11, 45-DO-214, and 45-DO-285), and Kartar NISP=10 (45-OK-11).

Ovis canadensis NISP = 1947

Mountain sheep occur in archaeological sites in eastern Washington with some regularity. The presence of mountain sheep is somewhat difficult to interpret, however, because references to it in the ethnographic and early trapper-settler literature are rare. Moreover, when competition with man and domestic stock for range became severe during historic times, the habitat preference of this species appears to have changed (Manville, in Monson and Sumner 1980). Further, modern distributions have little bearing on prehistoric distributions as most of the present day populations are (re)introduced (Ingles 1965:441; see also Lyman and Livingston 1983).

DISCUSSION

Conclusions drawn from faunal remains, whether regarding cultural use of biotic resources or environmental reconstruction, are subject to two kinds of biases: 1) those intrinsic in the theoretical and methodological approach to the treatment of faunal materials, and 2) those inherent in a particular body of faunal data due to historical factors that affected the deposition, preservation, collection and analysis of any given assemblage of bones. Both kinds of biases have been treated in some detail elsewhere: the former in Klein and Cruz-Uribe (1984), Shipman (1981), Behrensmeyer and Hill (1980), Gifford (1981), Monks (1981), Lyman (1982), Grayson (1979, 1983, and references therein); the latter in the Research Design for this project (Campbell 1984).

SAMPLING AND DATA COLLECTION

Excavation units at the sites were selected in two stages. In the first stage a 0.5% sample of the site area was chosen using a variant of a stratified systematic unaligned random sampling design. Then additional units were chosen in a purposive manner to allow investigation of features or other aspects of the site that were discovered in the process of excavating the initial sample. All sediments excavated were screened through 1/8th-inch mesh screen.

Faunal material from both probabilistic and purposive units have been combined in this summary. By combining the samples we have incorporated as much of the faunal data as possible into a series of discrete faunal assemblages that are comparable to other reported assemblages from the Columbia Plateau. Combining samples also simplifies the calculation and presentation of analytic procedures. In the interest of summarizing the information gained from the Chief Joseph faunal assemblages it is more expedient to treat the two kinds of samples as a single assemblage than to attempt to interpret each separately.

It should, however, be noted that in combining the probabilistic and purposive samples we have violated the assumption of random sampling made in most statistical procedures. However, all statistical tests used here in which the randomness assumption is made are known to be robust enough to allow at least modest violations of the assumption. Interpretation of test results has been kept conservative in view of the above. The data necessary to separate the assemblages into probabilistic and purposive samples is available upon request and undoubtedly would make an interesting study on the effects of sampling.

QUANTIFICATION

It was stated above that the assemblage has been presented in this report using NISP (number of identified specimens) as the unit of quantification. There are two units of quantification in common use among faunal analysts: NISP and MNI (minimum number of individuals represented by the identified specimens). Each of these measures has fundamental problems that hinder its use in a meaningful analyses. NISP suffers from element interdependence which violates the assumption of independence of sampled elements when using statistical tests of significance; and MNI, which meets the independence requirement, tends to overrepresent those taxa that are rare (Grayson 1979, 1983).

In the project descriptive site report series faunal data are presented using both measures of abundance for two reasons. The first is to assure comparability of the Chief Joseph faunal data with other Plateau assemblages. The second is that even though each measure has problems, and probably because of those very problems, much interesting information is contained in the relationship between the two measures of abundance. Further, in the descriptive site reports MNI values were calculated by both analytic zone and site to circumvent the effects of aggregation as much as possible or at least to allow the effects to be seen. In this report NISP was chosen as the appropriate measure to circumvent the problems of variable sample sizes, fluctuation of the value of MNI with aggregation technique and the variable volume of sediments contributing to each analytic zone. A brief discussion of the relationship between the two measures in this data set may serve as a disclaimer of the general validity of one measure over the other, and as a cautionary note to be kept in mind in evaluating conclusions drawn from this, or any other, body of faunal data.

Relationship between MNI and NISP

Ducos (1968), Casteel (1977), and Hesse (1982) have demonstrated it is possible to describe the typical relationship of the two measures of abundance through the use of a regression function of the general form:

$$MNI = a\,(NISP)^b$$

The regression function was derived as a general model which could be used to predict the number of individuals represented in an assemblage, given a known sample size. Casteel recognized that deviations from the curve defined by this model would occur as the result of: 1) investigator biases and ability; 2) recovery technique and collection bias; 3) variations in techniques used to calculate MNI; 4) the way the samples were aggregated into units of analysis; and 5) the nature of the sample itself

Casteel's analysis included samples from numerous areas of North America, Eurasia and Central America, encompassing a diverse range of aggregation methods, sample sizes, investigator biases and operational definitions of the MNI index. The Chief Joseph fauna was all collected using the same field procedures, and identified by analysts working together and comparing identifications. All MNI values were determined using the same operational definition. Aggregation units were derived in the same manner for each site. This means that the factors designated by Casteel as influencing the relationship between MNI and NISP have been controlled for either mechanically or theoretically with the exception of sample size and the variables of interest--changes in faunal composition and abundances, that is, the nature of the sample itself.

Fitting a regression curve to the paired MNI and NISP values for the Chief Joseph assemblages reveals a relationship that is described by the first function in Table 12-2. The relationship between the two measures ($r^2 = 0.55$) is significant at $p<0.0005$. It is of interest to note that the amount of variation explained by regression is not great in spite of the fact that many of the sources of variation suggested by Casteel have been controlled.

Table 12-2. Results of regression analysis of the relationship between MNI and NISP for the Chief Joseph Archaeological Project faunal data.

Taxon	N	Regression Equation	r^2	P	s
All taxa	562	$-0.051\mathrm{NISP}^{0.36}$	.55	<.0005	0.51
Small mammals	352	$-0.135\mathrm{NISP}^{0.51}$	.74	<.0005	0.41
Carnivores	69	$0.027\mathrm{NISP}^{0.02}$	.01	<.25	0.17
Artiodactyls	165	$-0.220\mathrm{NISP}^{0.46}$	.44	<.0005	0.46
Leporids	24	$-0.043\mathrm{NISP}^{0.13}$	.39	<.0005	0.11
Sciurids	69	$-0.135\mathrm{NISP}^{0.30}$	.49	<.0005	0.40
Small mammals[1]	253	$-0.106\mathrm{NISP}^{0.53}$	.79	<.0005	0.39
Carnivores[1]	62	$0.014\mathrm{NISP}^{0.04}$	.02	<.25	0.17
Elk	22	$-0.030\mathrm{NISP}^{0.06}$	.16	<.05	0.13
Deer	58	$-0.413\mathrm{NISP}^{0.35}$	.65	<.0005	0.54
Antelope	26	$-0.070\mathrm{NISP}^{0.14}$	.25	<.005	0.29

1. Small mammals other than sciurids or leporids.

2. Does not include 45-OK-258 dog or 45-DO-326 badger.

Grayson (1979:223) argued that, because the MNI for any series of taxa can be predicted from the NISP for that sample, NISP provides much the same information on taxonomic abundance as does MNI. He also suggested that much could be learned from studying the variability in MNI values not predicted by NISP. Regression analysis of the Chief Joseph faunal data has allowed us to look at these assertions in some detail. Regressing the MNI on the NISP for all genera in each analytic zone yields a highly significant correlation, ($r^2=0.55$, $p<0.0005$), demonstrating that if what we are interested in is taxonomic abundance and if the relationship between the two measures of quantification is known, then only one measure is necessary. Cases where the relationship does not hold can easily be recognized through examination of the residuals from the regression analysis (Figure 12-1).

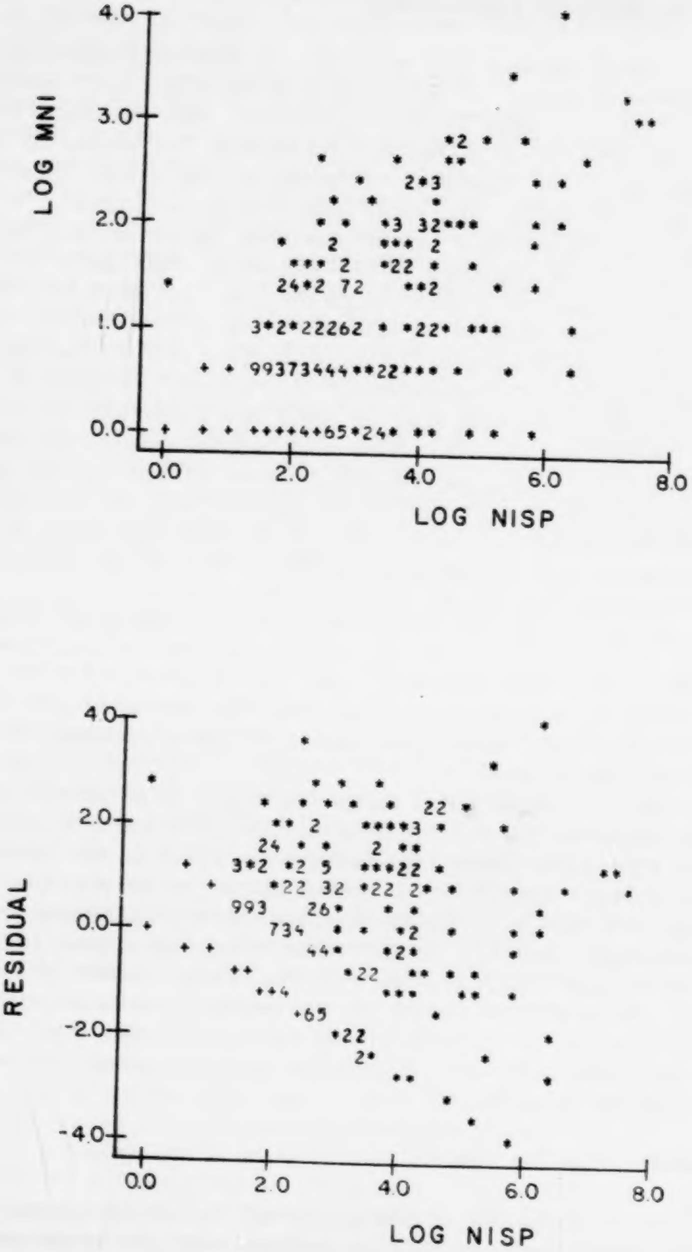

Figure 12-1. Regression and residual plots for all MNI and NISP data pairs (N=562).

Variations in the MNI/NISP Relationship

The relationship between MNI and NISP, as described above using a curvilinear regression model, is empirically defined and will change depending on the series of taxa included in the regression. How the field from which the function is derived is delimited will determine the values of the variables in the equation. Compare, for example, the values obtained by Ducos (1968), Casteel (1977), and Klein and Cruz-Uribe (1984).

The strength of the correlation between the variables also depends on the particular series of taxa included in the analysis. The low r^2 value for the Chief Joseph assemblages ($r^2 = 0.55$) suggests that including all the data in a single analysis may mask underlying systematic relationships that are potentially interesting and useful in understanding the archaeological meaning of taxonomic abundances. The large amount of residual variability suggests that there is at least one remaining variable not accounted for by this relationship. Peters and Raelson (1984) have demonstrated that predicting population density for living populations (number of individuals per km^2) depends not only on the size of the individual but also on the trophic level. They found that the number of individuals of a given species in a community could be predicted by size of the area censused, but if the community was broken into subcommunities on the basis of body mass and trophic level the relationships are different for the different subassemblages. Peters and Raelson's study incorporates variables for living populations (number of individuals and size of area censused) that correspond well to the variables MNI and NISP. The correspondence of the first variables in each study (individuals) is obvious. The second variables (area censused and NISP) are both measures of sample size.

The case has been clearly and correctly argued that sample size is the independent variable in the relationship between MNI and NISP (Grayson 1979). The reason for making the comparison between sample size and number of identified individuals has, to date, been a matter of determining which is the appropriate measure to use in terms of which is least affected by factors of deposition, breakage, recovery, etc. It has also been argued in this respect that we can never know the true nature of the living community of the past (Grayson 1979). However, the nature of the recovered bone sample also must bear some relationship to the once living fauna. Whether the living fauna is an entire natural community or a culturally selected subset of the natural community is another question.

Effects of Subdividing the Field

To examine the influence of the nature of the living community on the archaeological assemblages, regression analyses were performed after dividing the Chief Joseph assemblage into three subassemblages: small mammals (insectivores, lagomorphs and rodents), carnivores, and artiodactyls. When only the small mammals are included in the analysis the relationship between the two measures of abundance is even stronger than for the total assemblage as indicated by the increase in r^2 (r^2=0.74, $p<0.0005$). However, for both the carnivore and artiodactyl subassemblages the relationship between MNI and NISP is not as strong. In fact, for carnivores the relationship is statistically significant at only p=.25.

Comparison of the regression analyses for the three subassemblages (Table 12-1) demonstrates that the relationship between the two measures of abundance is dependent on the series of taxa included in the analysis. It is suggested here that the relationship described between the measures for the entire assemblage tells us little of interest other than that if enough data pairs are included in the composite the expected relationship will emerge. But if broken into subassemblages, the relationship varies significantly among subassemblages, both in shape and strength of correlation (Figure 12-2, 12-3, and 12-4, see Bobrowsky 1982 for similar findings). These regression analyses clearly show that while the relationship in the small mammal assemblage may be considered predictive, it would be misleading to attempt to predict the number of individual carnivores represented from the number of identified carnivore specimens for any of these assemblages, even with the comparative data base now available. Further, if the relationship between MNI and NISP is not significant, there is no reason to assume that relative abundance of taxa determined using one measure will reflect relative abundance using the other measure, even at the ordinal level.

The Effects of Fragmentation

Earlier, the data for several individual taxa from a selected set of Chief Joseph sites were analyzed separately (Livingston 1983). In that analysis it was observed that the relationship between MNI and NISP varied among taxa in a systematic manner, and that as evidence of fragmentation increased the slope of the regression line decreased. That is, as assemblages became more fragmented it took larger numbers of identified specimens to define additional individuals. It was also noted that the effects of fragmentation in taxa with considerable evidence of butchering would make those taxa **appear** more skeletally complete than taxa deposited by natural mechanisms if an index such as the one suggested by Thomas (1971) were used.

Thomas's index is based on the ratio of NISP/MNI, which he used to define the relative skeletal completeness of taxa. He argued that the more skeletally complete a taxon was the more likely that taxon was introduced into a site by natural mechanisms; conversely, the fewer elements per individual, the more likely humans were the primary agents of deposition. The assumption was that people are likely to disarticulate and scatter the skeletal parts of individual animals, while animals that die of natural causes on the site are more likely to be deposited in one place. Hence, once a single specimen of a naturally deposited individual is recovered, the chances are very good that other elements of the same individual will also be found. The dispersion of skeletal parts of animals that were used by people decreases the likelihood of finding many parts of the same individual.

If, however, the specimens are extremely fragmented, as occurs when bone marrow is extracted, many pieces of the same element may be deposited together. Consequently, inferring the agent of deposition from the number of

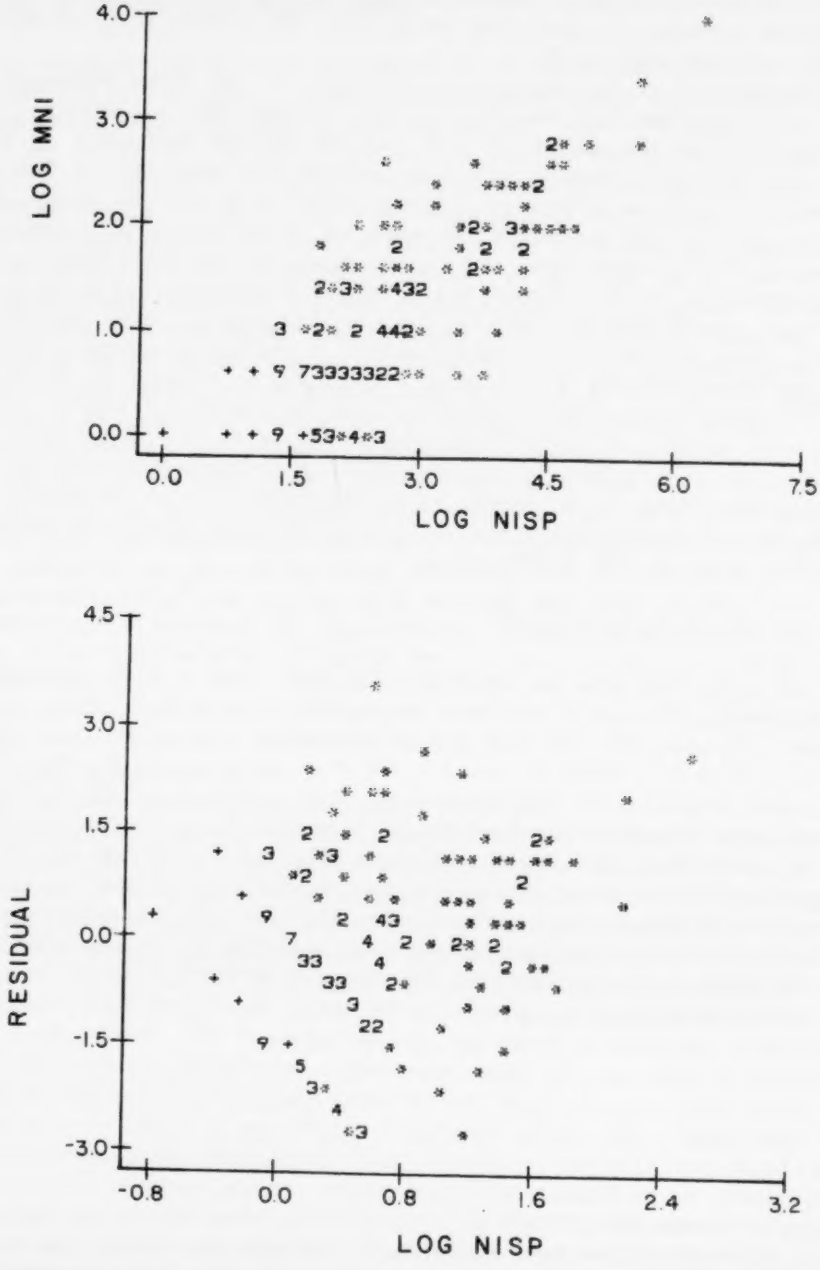

Figure 12-2. Regression and residual plots for small mammal MNI and NISP data pairs (N=352).

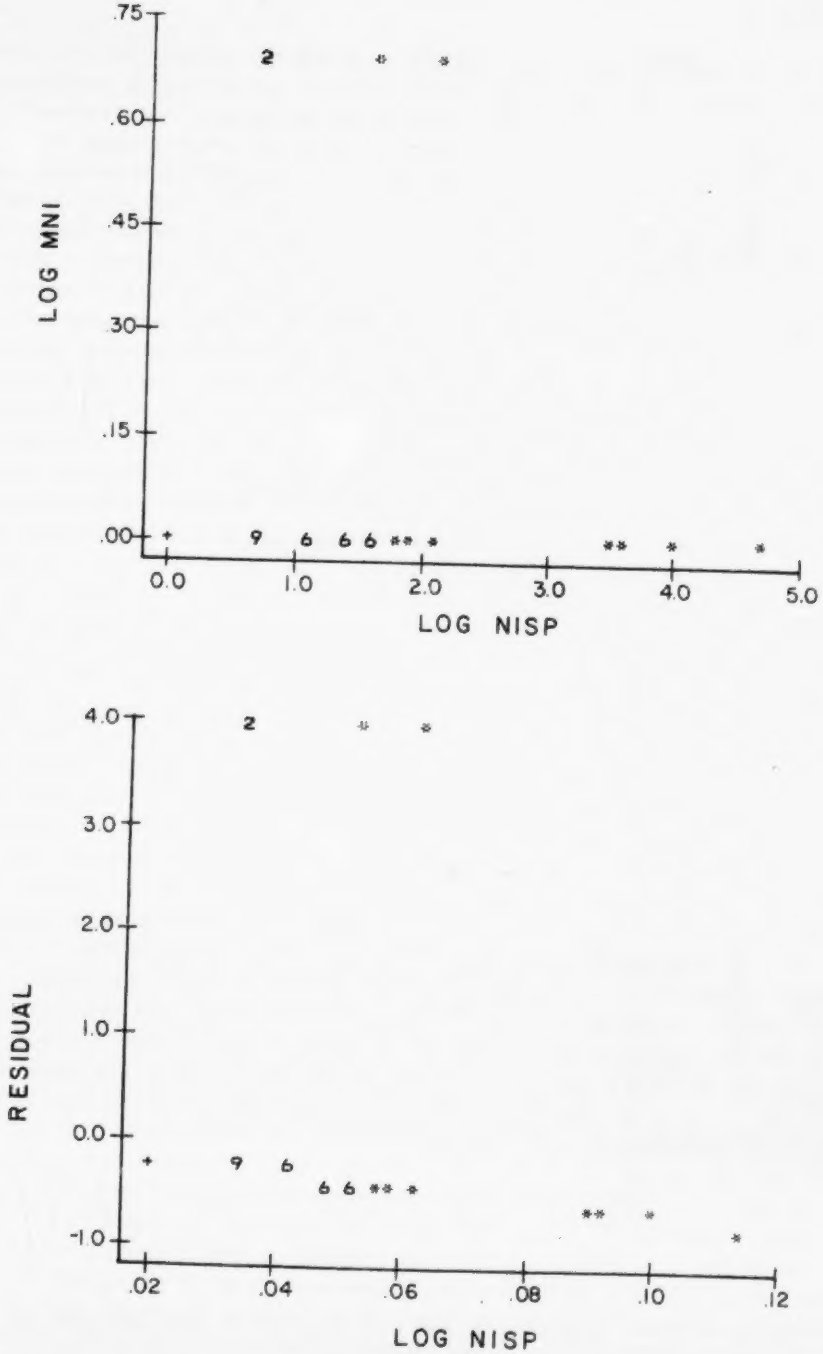

Figure 12-3. Regression and residual plots for carnivore MNI and NISP data pairs (N=62).

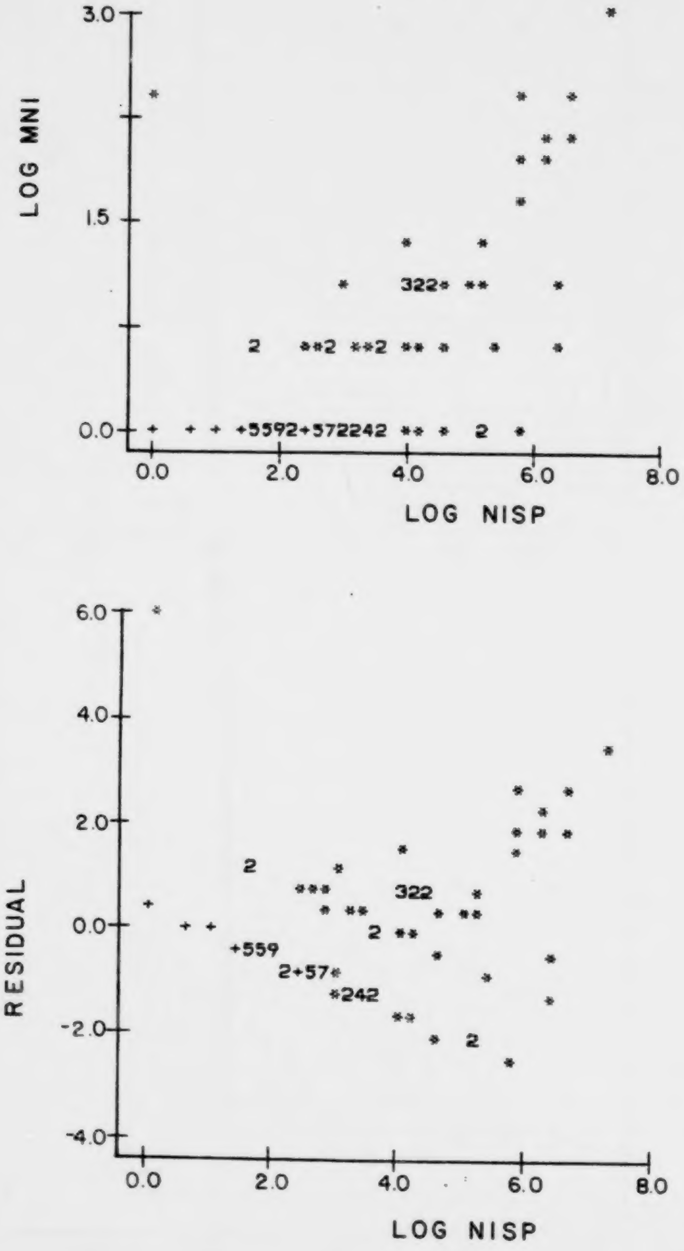

Figure 12-4. Regression and residual plots for artiodactyl MNI and NISP data pairs (N=165).

specimens per individual, or skeletal completeness, would have to be reversed from the manner suggested by Thomas. Using an index that cannot distinguish between complete and fragmented specimens, butchered, or culturally deposited, animals will **appear** more skeletally complete than naturally deposited animals. Klein and Cruz-Uribe (1984:30) observed this phenomenon in the Klasies River Mouth faunal data and attributed the lack of fit between their data and Casteel's model to varying degrees of fragmentation. They argued that the greater the fragmentation, the greater the difference between the NISP and MNI for a species. In other words, the individuals would **appear** more skeletally complete if only the number of specimens per individual is used without making a distinction between whole and broken bones.

Subdividing each faunal assemblage into groups of similar taxa allows demonstration of the affects of fragmentation alluded to by Klein and Cruz-Uribe (1984) and discussed by Livingston (1983). If taxa for which there is evidence of butchering, burning, or other indications of cultural intervention in the depositional process are analyzed separately, it is apparent that the effect of fragmentation is to pull the regression line closer to the axis of the independent variable (NISP). The lower slope is expected because the more fragmented a sample, the more specimens it takes to define an individual.

The decrease in the slope of the regression line for the artiodactyls was previously attributed to the effects of fragmentation in the course of butchering (Livingston 1983). It now appears that the lack of correspondence between the two measures of abundance in the large mammals may also be a result of the fact that many small portions of elements of the artiodactyls are identifiable to genus/species. Easily identified elements such as antler, horn core and small pieces of broken teeth, either are not represented in the small mammal skeleton or are not recovered when broken. Antler, horn core and teeth become fragmented, not so much in the process of butchering, but as an effect of decay. Often, these are the fragments that account for most artiodactyl elements identified to genus or species; yet, no matter how many fragments of tooth enamel, antler, or horn core are identified, it is generally impossible to distinguish more than a single individual. Most butchered longbone and axial elements can be identified only to size category. Thus, it is size and/or identifiability of fragmented elements of the taxon and not necessarily butchering that is controlling the slope of the regression line describing the relationship between MNI and NISP.

The lack of correlation ($r^2 = 0.01$) between the two measures of abundance for the carnivores undoubtedly arises from the scarcity of carnivores in all of these assemblages. In most components where carnivores were identified, there is little reason to believe more than a single individual of any carnivore taxon is represented, regardless of the number of identified elements. Although carnivores are most frequently represented by one or a few elements, in two components relatively complete individuals were recovered: the dog burial at 45-OK-258 consists of at least 110 elements of a single individual, and 56 of the 57 badger elements from 45-DO-326 represent a single individual that probably died of natural causes in its rockshelter home. If these individuals are excluded from the analysis the correlation between the measures improves ($r^2 = 0.02$), but remains insignificant ($0.10<p<0.25$).

The regression analysis of MNI and NISP for the small mammals from Chief Joseph reveals the relationship predicted by Casteel. There is a fairly high correlation ($r^2 = 0.74$) between MNI and NISP for the small mammals. If, however, we look at the two small mammal families for which there is evidence of human involvement in the depositional process, the relationship is somewhat different. For both the sciurids and leporids there is evidence in the form of burned elements and/or distributional information (see above) that the recovered bones represent animals deposited by people. The correlation of MNI and NISP in these families is $r^2 = 0.39$ for the leporids, and $r^2 = 0.49$ for the sciurids. When the leporids and sciurids are removed from the small mammal assemblage, the remaining assemblage shows a higher correlation between the two measures of abundance ($r^2 = 0.80$, $p<0.0005$). The lower correlation in the relationship for the sciurids and leporids again may be an effect of fragmentation. Although leporids and sciurids are taxa which appear to have been deposited by human activities, they are among the largest genera included in the small mammal series. The size difference between the sciurids and leporids on the one hand and the mice and gophers on the other is such that a 1/8 inch screen, as was used to collect these assemblages, will recover many phalanges, metapodials, tarsals and articular ends of broken longbones of the leporids and sciurids. Those same elements of the mice and gophers generally will not be recovered.

Conclusions

The argument that NISP contains all the information in MNI may well be an effect of considering primarily the small taxa. As can be seen from the analysis described here the small taxa are less likely to vary with fragmentation. That the small taxa vary less with fragmentation may be a function of people not having been involved in their deposition, the inability to recover the fragments of small elements using standard archaeological techniques, or the increased difficulty of recognizing tiny fragments of elements that are small even when they are whole. Ultimately, although in many assemblages the correlation between MNI and NISP is very strong and highly significant, the relationship is not as predictive as Casteel and Ducos had hoped. It is, however, telling us something about the nature of the bone assemblage. Because the nature of the relationship between MNI and NISP varies depending on the empirical content of the field, as these assemblages demonstrate, it is inaccurate to claim that MNI values can always be tightly predicted from NISP counts (Grayson 1979).

If, in fact, the variation in the relationship between MNI and NISP is due to either fragmentation or skeletal completeness, this analysis also demonstrates that the assumption that interdependence is randomly distributed across taxa (see Grayson 1979, 1983) is not well founded if assemblages of all recovered bone elements are considered together. The interdependence of faunal specimens is of concern not only because each identified element does not represent a discrete individual, but also because different individuals or different taxa may be represented by different numbers of elements. It has been demonstrated here that the correlation between the measures of abundance varies with the taxonomic content of the field. If, in fact, fragmentation and/or skeletal completeness is controlling the shape of the line, then interdependence is **not** randomly distributed throughout the assemblage, but varies significantly among taxonomically defined subassemblages. Therefore, if we want to compare taxa quantitatively using NISP by making the assumption that interdependence is randomly distributed among the taxa, we must do it within a series of taxa for which we can state some reason for making the assumption. For these reasons all further comparisons here will be made using series of taxa of comparable size and trophic level--small mammal, carnivore, artiodactyl.

BIOGEOGRAPHY

Modern conditions in the project area, even prior to the last rise in pool level, cannot be used to calibrate the conditions and resources available to people during the last 6-7,000 years. The original riparian community, although possibly never extensive or well developed, has been flooded along most of the river. The impact of the loss of riparian vegetation and soils to animal life is difficult to assess, but has been shown to have been significant in other similar areas (Lewke and Buss 1977). In terms of understanding the prehistoric record, it leaves us with a poor basis for comparison. Further, introduction of domestic animals (Bos taurus, Equus caballus, Ovis aries, and Sus scrofa), introduction of agricultural plants, and industrial changes of the landscape (dams, roads, towns) give the environment a very different appearance than it must have had in the past. A number of taxa known to have lived in eastern Washington in the past are no longer there (Bison bison, Ursus arctos, Canis lupus). Some are present only as a result of reintroduction (Antilocapra americana, Castor canadensis). The ranges of some animals have been reduced so that they no longer include the project area (Cervus elaphus, Antilocapra americana). The process of faunal turnover is still going on. Payne et al. (1975) list seven mammals that are rare, threatened, or occur in such low frequencies that their status is unknown along the mid-Columbia (Table 12-3).

Simple occurrences of taxa and their relative abundances in the archaeological assemblages attest to the changes that have occurred in the mammal populations living in the project area during the last 6-7,000 years. Of those seven mammals considered rare, threatened or of uncertain status by Payne et al. (1975), elements of three, and possibly five have been identified in the faunal remains from the Chief Joseph sites (Table 12-3), as have elements of taxa now extinct in eastern Washington (Bison bison, Canis lupus, Ursus arctos).

Table 12-3. Mammals that are now rare, threatened, or of uncertain status along the mid-Columbia River (from Payne et al. 1975).

Taxon	Occurrence in Project Archaeological Assemblages		Reintroduced	Locally Extinct
	Species Occurs[1]	Genus Occurs[2]		
Dipodomys ordii				
Martes americana	X			
Martes pennanti	X			
Gulo gulo				
Canis lupus				X
Lynx lynx		X		
Ursus arctos				X
Antilocapra americana	X		X	
Ovis canadensis californicus		X	X	
Bison bison				X

1. Species found in one or more of the Chief Joseph Archaeological project assemblages.
2. Genus found in one or more of the Chief Joseph assemblages. Some elements could not be assigned to species, may represent the species indicated here.

An earlier comparison of the faunal assemblages from the small sites revealed distinct patterns of presence and absence on the north and south sides of the Columbia River (Livingston 1983). *Ondatra*, *Ursus*, *Lynx*, and *Erethizon* were not found on the south side of the river and *Sylvilagus*, *Spermophilus*, *Mustela*, and *Taxidea* were not found on the north side. It was felt that the patterns were possibly due to sample size effects evident even among these small assemblages, and that a nominal level analysis, interpreting only taxonomic presences and absences, would be misleading and premature (Livingston 1983). Some taxa are expected to have large living populations on the north side of the river due to the proximity of the mesic Okanogan Highlands, others on the south side of the river due to the proximity of the xeric Columbia Plateau. Rare taxa, those that occur in low frequencies, usually will not be found in small assemblages (Wolff 1975). As anticipated from previous work in the Columbia Basin (Osborne 1953), many of the nominal patterns previously noted disappearred when the larger assemblages were included in the analysis. However, variations in relative abundances between the north and south side of the river remain to varying degrees, depending on how the assemblages are quantified.

Artiodactyls

Six genera of artiodactyls were recognized in the archaeological assemblages. Of these six, one (*Equus caballus*) is an introduced domesticate. Of the remaining five, three (*Cervus elaphus*, *Ovis canadensis*, *Bison bison*) are no longer found in the project area, and one (*Antilocapra americana*) is now near the area only because it was reintroduced in the Umatilla, Oregon and Hanford, Washington regions. The biogeography of the remaining genus of artiodactyl (*Odocoileus*) is poorly understood archaeologically in eastern Washington in spite of the fact that it is often the most abundant mammalian food resource represented in archaeological sites.

The biogeography of deer is poorly understood primarily because it is extremely difficult to distinguish the two species of deer from the elements commonly preserved in archaeological sites. The probable species of deer was determined, using discriminant analysis, for as many of the project deer specimens as possible. Fifty-two mandibles were identified to the species level using this multivariate technique. Although this admittedly is a small sample, it is the first of any appreciable size for the Columbia Plateau. The ratio between deer identified as mule deer (*Odocoileus hemionus*) and those identified as white-tailed deer (*O. virginianus*) is 1:1.5, 1:1.6, and 1:1.5 for Coyote Creek, Hudnut and Kartar Phases respectively (Table 12-4). The prehistoric stability of the ratio of mule deer to white-tailed deer is undeniable, yet modern wildlife survey data show the white-tailed deer as rare local migrants (Erickson et al. 1977:174). The abundance of white-tailed deer in the archaeological assemblages may reflect a pattern of hunting in the uplands or a loss of white-tailed deer near the river associated with the loss of riparian habitats.

Table 12-4. Ratio of mule deer to white-tailed deer by phase.

Phase	*Odocoileus hemionus* (NISP)	*Odocoileus virginianus* (NISP)	Ratio
Coyote Creek	2	3	1:1.5
Hudnut	14	23	1:1.6
Kartar	4	6	1:1.5

However the concurrent loss of other artiodactyls (antelope, sheep, bison, elk) suggests that the decrease in white-tailed deer is part of a more extensive environmental phenomenon. Decline or extirpation of indigeneous artiodactyl populations has been attributed to introduction of firearms (Suckley and Cooper 1860:135, Schalk and Cleveland 1983:39-41), introduction of domestic livestock and usurpation of their natural habitats by Euroamericans (Cowan 1936, US Army Corps of Engineers 1975:51). While it is entirely possible, and probable, that Euroamerican settlement had an adverse effect on the local artiodactyl populations, an alternative, or ancillary, explanation of the demise of the artiodactyls is offered below. Whatever the cause, it is clear that the indigeneous artiodactyl fauna in the project area was more diverse throughout the prehistoric period than it is now.

Small Mammals

Assessing biogeographic changes in small mammal taxa is also made difficult by the lack of a modern basis for comparison. An attempt was made to survey the small mammals on one of the sites (45-OK-2) during the summer of 1982. The effort was abandoned after two unsuccessful nights. Lack of success was attributed to full moon and high water, which may have flooded most burrows and nest sites. Published surveys also indicate low return on trap nights expended. Erickson et al. (1977) report spending September 3 to October 17, 1974 and July 15-28, 1975 trapping in the area. Averaged over the three habitat types studied, their return was 3.26 animals per 100 trap nights. They succeeded in capturing individuals of *Peromyscus maniculatus* (72% of total captures), *Perognathus parvus* (20% of total captures), *Neotoma cinerea*, *Microtus montanus*, *Eutamias minimus* and *E. amoenus*. Examination of raptor nests and raptor pellets added *Thomomys talpoides*, *Lagurus curtatus*, *Reithrodontomys megalotis* and *Sorex* sp. to the census of species. As they noted, however, the taxa identified as raptor prey may have been hunted beyond the study area (Erickson et al. 1977). Their conclusion, as was my own, was that much of the project area currently supports a meager population of small mammals, especially during and after the peak of summer heat and dryness.

The rodents identified in the archaeological assemblages present the appearance of a community somewhat different from that observed by Erickson et al. (1977). The most abundant rodent in most of these archaeological assemblages is *Thomomys talpoides* and second in abundance is *Perognathus parvus*. *Eutamias minimus*, *E. amoenus*, and *Reithrodontomys megalotis* were not recognized in any of the archaeological assemblages. These differences may be due to the differences in recovery techniques used to obtain the modern and prehistoric records, and the ethology of the species in question, rather than faunal turnover or changes in the environment in the last 4-5000 years. *Thomomys* and *Perognathus* are the most likely of all the rodents to become preserved in archaeological deposits as a result of their burrowing behavior, but are not easy to capture with conventional live or snap traps. *Peromyscus* is often the most abundant rodent in a living fauna, and is quite easy to capture in a baited trap. However, their surface dwelling habits leave them more vulnerable to predators or scavangers than to preservation in archaeological deposits.

Modern wildlife surveys of the area found, not unexpectedly, limited numbers of beaver (*Castor canadensis*) and muskrat (*Ondatra zibethica*). The modern unstable water levels periodically flood the houses and burrows of these aquatic mammals or isolate them from water, rendering them vulnerable to drowning or predation (Erickson et al. 1977:237). In tributaries to the main channel, however, they still flourish, their populations sometimes reaching such high densities that fur trapping, rather than being detrimental to population stability, reduces competition among individuals and preserves the value of their pelts (D. Stewart, personal communication).

Most specimens of furbearing rodents are in Type 1 sites, which are the most complex sites with the largest faunal assemblages. It is uncertain whether the occurrence of the furbearers is a function of site location, cultural activities at the site, or an increase in taxonomic diversity with the increase in overall sample size of the faunal assemblage (Jones, Grayson, and Beck 1984). Furbearing rodents occur in all phases in very low numbers, suggesting that the animals lived in the area throughout the period of time represented in the sites. The low frequency of these taxa in the sites may reflect low population densities of furbearing rodents near the sites when the Columbia River was a fast flowing river. If the main prehistoric furbearing rodent populations were located on tributaries away from the main channel, as are modern populations, they may have been more abundant and used more frequently than indicated by their occurrence in these archaeological assemblages; their low frequency of representation may simply reflect skinning and/or butchering away from the floodplain sites.

It has been observed that both rabbits (Sylvilagus) and hares (Lepus) now occur in surprisingly low numbers in the project area (Erickson et al. 1977:233), especially on the north side of the river (personal observation). The low frequency of sitings of leporids may be a function of the time during which survey occurred. The small leporid populations during the 1970's has been attributed to high numbers of coyotes; when the coyote poulation is suppressed, as during the recent parvovirus epidemic, the leporid population increased (D. Stewart, personal communication). Observation of large numbers of hares on the south side of the river during the parvovirus epidemic supports the contention that high population densities can be achieved by leporids in this area. However, the hares observed were Lepus californicus (Payne et al. 1976), a species thought to have invaded Washington around the turn of the century (Couch 1927). The response of this recent immigrant to local environmental conditions may not be representative of past population dynamics of the indigeneous species.

The archaeological record for leporids in this area is minimal. The extremely small number of leporid elements in all time periods and all sites resembles the current low numbers. Alternative explanations for the low frequency of archaeological leporids include: 1) leporid numbers were suppressed throughout the last 5-6,000 years by high coyote populations, 2) leporids were not used by prehistoric human populations, 3) leporids were used by prehistoric people in a manner that is archaeologically invisible, or 4) leporids have never been abundant in the project area. That 16% of all the leporid elements recovered from the archaeological sites are burned suggests the second alternative above is unlikely. The available evidence offers no way of choosing among the other three alternatives; it is suggested here that the alternatives are not mutually exlusive and may all have been factors contributing to the low frequency of leporid elements in project sites. The relative scarcity of leporids in other eastern Washington archaeological faunas suggests that the reasons for low abundance are regional in scale.

Carnivores

The archaeological assemblages contain four species of canids (Canis latrans, C. lupus, C. familiaris and Vulpes vulpes), two species of bear (Ursus arctos, U. americanus), six species of mustelids (Lutra canadensis, Martes americana, M. pennanti, Mustela frenata, Taxidea taxus, and Mephitis mephitis) and at least one species of Lynx. This is a large and varied series of carnivores in view of both the geographic location and open nature of these sites. Some of these taxa are cosmopolitan (C. latrans, M. frenata, T. taxus, M. mephitis, Lynx) or prefer riverine habitats (L. canadensis). They probably lived near the archaeological sites in the past as they do today. Others, such as Vulpes vulpes, Ursus arctos, Martes americana, and M. pennanti are now found in more remote habitats at higher elevations. Although there is the possibility that some or all of these carnivores lived near the sites in the past, at least some of the archaeological specimens show evidence of butchering or burning indicating human intervention in the depositional process. It would be purely speculative to attempt to reconstruct their past distribution in view of the contribution of people in their depositional process.

The low number of carnivores today has been attributed to the sparse riparian development that has occurred since the river has been dammed. In the wildlife survey conducted by Payne et al. (1975:157-158) coyote (Canis latrans) and racoon (Procyon lotor) were the most commonly observed furbearers. It is worthy of note that despite the recovery of several relatively rare taxa that are not expected to have lived at the elevation or in the habitats afforded in the area of the sites, no elements recognized as racoon were encountered.

Conclusions

The pattern that appears to emerge, then, is that over time there has been a loss of species, especially those with large individuals (grizzly bear, bison, elk, sheep, antelope). To a lesser extent there has been a loss of medium sized animals (wolf, marten, fisher, otter). There has also apparently been a decrease in population size of species not totally extirpated (white-tailed deer, fisher, marten). We are unable to assess the stability of small taxa.

The cause of the loss of native animals in this area cannot be determined without additional information. As mentioned above, one explanation that has been suggested is the introduction of guns and horses by Euroamerican who also settled the rangeland of the artiodactyls. Because ranching appears to have been less successful in the project area than elsewhere in the Columbia Plateau (Meinig 1968), and early explorer records indicate low population densities at the time of settlement, climate may also be suggested as an alternative factor that may have affected the indigeneous populations prior to Euroamerican settlement. The evidence for climatic change in the project area is reviewed below.

ENVIRONMENTAL INDICATORS

An interdisciplinary body of data bearing on the Holocene climate of eastern Washington has recently become available. These data include pollen profiles (Barnosky 1985; Blinman 1978; Davis et al. 1977; Mack et al. 1976, 1978a, 1978b, 1978c, 1979, 1983; Nickman 1979; Dalan this volume), sedimentology (Hassan 1977) and archaeological faunas (Lyman 1984, in press; Lyman and Livingston 1983; Chatters 1984). Syntheses of these data suggest that before 9500 B.P. environmental conditions in eastern Washington were cooler and/or moister than at present. Between 8500 B.P. and 4500 B.P. the environment was warmer and/or drier than at present. Between 3500 B.P. and 2500 B.P. conditions apparently became similar to modern conditions in the more arid areas, but were cooler and/or moister at higher elevations. By 2500 B.P. all areas resembled their modern environments. These conditions have remained relatively stable into historic times, with the possible exception of a slightly more arid episode between 1500 B.P. and 500 B.P. (Lyman in press, Chatters 1984, Schalk et al. 1983, Mehringer 1985). For the most part these reconstructions represent filling in of the details of a general trend of increasing warmth and dryness, interrupted by cool, moist intervals suggested by Butler (1978). However, rather than recognizing the cool, moist intervals as interruptions; recent environmental reconstructions tend to emphasize the hot, dry episodes which are seen as droughts (eg. Schalk et al. 1983). Because water is apparently a major limiting factor in the productivity of much of eastern Washington, especially in arid areas such as the Pasco Basin (Schalk et al. 1983), emphasizing the dry periods is a logical approach when the data permit recognition of droughts.

Although there are very definite differences between the archaeological faunas and the modern faunal communities in the project area as discussed above, the following section shows no obvious regional environmental changes, other than a possible gradual warming/drying trend, can be identified in these faunal assemblages. Evidence for environmental change or stability as reflected in the relative abundance of particular taxa is reviewed for the small mammal and artiodactyl categories. Because many of the taxa are deposited naturally in the sites, small mammals are potentially the best environmental indicators. The carnivores are not considered because of small sample sizes and the probability that they were transported by people from some distance. As discussed above, a number of carnivore taxa found in the archaeological assemblages are not currently found in the project area. Some, such as _Martes americana_ and _M. pennanti_ and other mustelids probably never lived in the area of the sites, but were captured in the uplands and brought back to the sites by people. It is harder to make a case for transport of artiodactyl taxa such as bison, elk, sheep and antelope. Although these taxa were obviously incorportated into the archaeological assemblages by people, their current range is so far from the vicinity of the sites and their carcasses are so large that it is unlikely that they were transported to the sites from their modern range. The frequency and relative skeletal completeness of occurrence of some of these taxa suggest they were procured from much closer to the sites than their modern range.

Small Mammals

Small species with relatively small geographic ranges and narrow environmental tolerances provide the best faunal indicators of past environmental conditions. The smaller mammals are generally considered a more reliable source of environmental data because it is more likely they were introduced by natural rather than human mechanisms, and thus to reflect environmental changes rather than changes in human preferences or activity patterns. Unfortunately, open sites such as those excavated in the Chief Joseph Project do not provide favorable conditions for the accumulation, preservation and recovery of the remains of small, environmentally sensitive taxa. While this does not mean that indications of environmental change are lacking, it does mean the data are less than ideal and as a result the changes seen will not appear pronounced. Further, in most cases the elements recovered from these sites were not ones that allow species level identification. Most of the small taxa in the project area are monospecific genera (Marmota, Perognathus, Thomomys, Peromyscus, Lagurus, Neotoma). But several genera may have had more than one species living in the area (Lepus, Sylvilagus, Microtus, Spermophilus). When more than one species of a given genus is represented in an assemblage, further masking of evidence of environmental change may occur as a result of undetected shifts between species within a genus. Inferences drawn from taxa with larger individuals are subject to the same kinds of problems. Further, it is often impossible to determine whether observed changes in relative abundances of larger taxa over time reflect adjustment of the taxon to changed environmental conditions, changes in man-animal interaction, or changes in man-animal relationships caused by environmental change.

Indication of past environmental effects on the faunal assemblages from these 18 sites may take one of two forms: replicative sequences from site to site, or reservoir wide shifts in relative abundances through time. Seeking replicative sequences in this set of assemblages is difficult because most of the site sequences are short or composed of such small assemblages that it cannot be determined whether differences in the assemblages amount to anything more than the vagaries of sampling. Reservoir-wide shifts in relative abundances may be seen by combining comparably aged assemblages from all sites. Creating such aggregated assemblages assumes that all included subassemblages were drawn from a uniform regional fauna. For the most part this assumption is reasonable given the close proximity and basic similarity in present environments of each of the sites. This procedure may, however, incorporate taphonomic or synchronic environmental differences that mask environmental differences over time or create the appearance of changes that did not occur. When both approaches are applied to the same data set, and similar trends are observed, greater confidence may be placed in the results.

Only one site, 45-OK-11, had a large enough sample of small mammals distributed across more than one phase to allow differences in relative abundances to be seen. The relative abundances of six taxa of small mammals indicate that environmental conditions at 45-OK-11 were relatively cooler and/or moister during the Kartar Phase (7000-4000 B.P.) occupation than during the Hudnut Phase (4000-2000 B.P.) occupation (Table 12-5). Because almost all Kartar Phase materials recovered in this project are from 45-OK-11, it is not possible to check this trend against the record from other project area sites. Other sites with Kartar phase components have very small faunal assemblages.

Table 12-5. Relative abundance of small mammals at 45-OK-11 by phase.

Taxon	Hudnut		Kartar	
	NISP	%	NISP	%
Thomomys	60	37.5	507	65.1
Perognathus	91	56.9	244	31.3
Peromyscus	4	2.5	14	1.8
Microtus	1	.6	14	1.8
Lagurus	3	1.9	0	0.0
Neotoma	1	.6	0	0.0
Total	160		779	

No pronounced change is apparent between the Hudnut and Coyote Creek Phases in small mammal representation, even in sites with large samples. At 45-OK-258 the only environmentally sensitive taxon for which there is an appreciable change is *Lagurus* but the difference is less than 4% (Table 12-6). At 45-OK-2 a similar picture emerges (Table 12-7). The slight shift in the relative abundances of *Thomomys* and *Perognathus* might be due simply to the older phase being from deeper deposits in the burrowing range of *Thomomys*. The most significant change is the slight increase in abundance of *Lagurus* in the Coyote Creek Phase assemblage. The general lack of change observed could indicate environmental stability over the last 4000 years. Alternatively, it could be due to including the drought seen by others at 1500-500 B.P. with the cooler, wetter time before and after it into one phase (Coyote Creek).

Table 12-6. Relative abundance of small mammals at 45-OK-258 by phase.

Taxon	Coyote Creek		Hudnut	
	NISP	%	NISP	%
Thomomys	31	43.7	107	46.9
Perognathus	29	40.8	90	39.5
Peromyscus	5	7.6	24	10.5
Microtus	3	4.2	6	2.6
Lagurus	3	4.2	1	.4
Total	71		228	

Table 12-7. Relative abundance of small mammals at 45-OK-2 by phase.

Taxon	Coyote Creek		Hudnut	
	NISP	%	NISP	%
Thomomys	62	53.9	219	70.6
Perognathus	40	34.8	69	22.3
Peromyscus	3	2.6	11	3.5
Microtus	5	4.3	7	2.3
Lagurus	5	4.3	2	.6
Neotoma	0	0.0	2	.6
Total	115		310	

Using the alternative approach suggested above, all assemblages for each time period were combined into a project wide assemblage (Table 12-8). In the project wide analysis the same taxa were included as in the previous two tables. The same trends appear in this table as in the previous analyses. There is a higher proportion of *Thomomys* in the older/deeper assemblages, and a relative increase in *Perognathus* in the later assemblages. There is also a continuous increase in *Lagurus* through time.

Table 12-8. Relative abundance of small mammals by phase for all sites.

Taxon	Coyote Creek		Hudnut		Karter	
	NISP	%	NISP	%	NISP	%
Thomomys	215	41.9	848	67.1	399	77.6
Perognathus	189	36.8	256	20.3	75	14.6
Peromyscus	25	4.9	74	5.9	18	3.5
Microtus	26	5.1	27	2.1	3	0.6
Lagurus	51	9.9	58	4.6	17	3.3
Neotoma	7	1.4	1	0.1	2	0.4
Total	513		1264		514	

A gradual warming and drying through time could be inferred from the changes in relative abundance of small taxa. The clearest change in abundance of small mammals is in the gophers and pocket mice. Gophers decrease from over 70% of the early small mammals assemblages to 30% of the late assemblages. Pocket mice, on the other hand, tend to show a fairly steady trend of increasing abundance through time. While these two taxa tend to prefer slightly different habitats in terms of effective moisture, it must be kept in mind that gophers burrow much deeper, and consequently would be expected to occur in greater abundances in the deeper deposits. These deeper deposits tend to be where the older assemblages are found. In other words, the relative abundances of pocket mice and gophers may be more tightly correlated with depth than with time and surface environmental conditions (Szueter 1982).

There also is a general tendency for sagebrush voles (*Lagurus curtatus*) to be found in increasing numbers through time. *Lagurus* is the most reliable indicator of environments in these assemblages because there is no indication that people were involved in the deposition of this taxon, it is a monospecific genera, and all sites lie on the lower boundry of its modern elevational range (Johnson 1948). If conditions were such that habitats either improved or worsened for this species the result would be a change in abundance relative to other taxa with slightly different requirements. *Lagurus* prefers habitats of dry sagebrush with little grass, while most species of *Microtus* prefer marshy or grassy habitats. *Microtus* appears to maintain a fairly stable and low abundance throughout, increasing only slightly through time. The increase in *Lagurus* then, may indicate a gradual drying and loss of grassland through time.

Artiodactyls

The only general trend that can be seen in the overall analysis of the total artiodactyl assemblage, compiled by time intervals for all project sites (Table 12-9) is the loss of the larger taxa. Loss of the artiodactyls in eastern Washington is a widely recognized phenomenon (Dalquest 1948, Ingles 1965, Lyman and Livingston 1983). The disappearance of these large mammals has generally been attributed to the effects of Euroamerican settlement as discussed above. The overgrazing explanation has been used to account for changes seen in the vegetation in the upper part of pollen cores. Overgrazing is generally seen as an increase in Chenopodiinae which is interpreted as a proliferation of weedy species invading after the destruction of the natural bunchgrass vegetation. A peak in Chenopodiinae at or shortly after contact has been observed in the cores from Wildcat Lake (Davis et al. 1977), Goose Lake, and Rex Grange Lake (Dalan, Chapter 3 and Appendix C).

Table 12-9. Relative abundance of artiodactyls by phase for all sites.

Taxon	Coyote Creek		Hudnut		Karter	
	NISP	%	NISP	%	NISP	%
Cervus	17	0.4	65	1.2	26	1.3
Odocoileus	3444	83.6	4505	85.1	1501	76.8
Antilocapra	155	3.8	36	0.7	59	3.0
Ovis	500	12.1	670	12.7	359	18.4
Bison	2	0.1	15	0.3	10	0.5
Total	4118		5291		1955	

In the Rufus Woods Lake area, however, overgrazing may not have been a major factor in the decimation of the native artiodactyls. There is no evidence that large herds of domestic livestock were ever pastured in this area. Horses were the first domestic ungulate in the Columbia Basin, arriving late in the 17th century (Haines 1938). The project area is thought to have been too arid for horses to thrive, and apparently the San Poil and Nespelem were not greatly influenced in their social or subsistence activities by the introduction of horses. The demand for cattle in this area began about 1855, but by 1885 much of the range land was still available for homestead. When the reservation was opened for non-Indian homesteading in the 1890s, it was found to be more profitable for wheat than cattle, but most land along the river was not settled until after the turn of the century. The sheep industry in the Columbia Basin paralleled the cattle industry. The Dawes Act in 1887 probably marked the beginning of the greatest grazing impact on the project area. This act allowed non-Indians to lease reservation land from tribal members. The leases made it profitable for Euroamericans to transport their livestock into the reservation for summer pasturage (Meinig 1968, see also Thomas et al. 1984 for a summary of the historic land use in the project area). By the time there is evidence for any appreciable number of domestic animals in the project area (mid 1800s) it is apparent that at least some of the native artiodactyls had already been decimated. There is little or no reference in journals of the explorers and trappers to bison, elk, or antelope living in the Columbia Basin at the time of contact.

The same phenomena could also be attributed to a gradual and continuous warming and drying trend during the last few thousand years that resulted in a loss of grassland and riparian habitats preferred by these taxa. At this point it is impossible to distinguish between the two possibilities. What is apparent is that the early (Kartar) and late (Coyote Creek) phases are both lower in taxonomic richness than the intervening (Hudnut) phase. However, the samples for the middle assemblages are much larger. What may appear to be less diverse assemblages may simply be the effects of smaller sample sizes failing to pick up the rarer taxa (Jones, Grayson, and Beck 1984). On the other hand, the middle (Hudnut) assemblages are less evenly distributed across taxa. In Hudnut assemblages deer represent a greater proportion of the artiodactyls. Thus, while the Hudnut assemblages are larger, allowing them to pick up more of the rare taxa, the abundances are very unevenly distributed among the taxa.

Relative abundances of species of deer show a similar trend towards loss of evenness between prehistoric and historic faunas. Throughout all three prehistoric phases the ratio of mule deer (_Odocoileus_ _hemionus_) to white-tailed deer (_O. virginianus_) was between 1:1.5 and 1:1.7 (Table 12-4). Modern wildlife survey data indicate that not only has the ratio shifted in favor of the mule deer, but white-tailed deer are now considered rare local migrants in the area of the sites (Erickson et al. 1977, Table 8.2). Recent white-tailed deer are known to have retreated upslope leaving lower elevation ranges to be taken over by mule deer throughout much of the Southwest (Brown and Henry 1981). Little is known of the nature of deer population species ratios for the Columbia Plateau or the intervening Great Basin as most deer recorded in historic times are mule deer, and archaeological deer elements have seldom been identified to the species level.

White-tailed deer apparently were abundant over much of Washington until about 1875, after which time they rapidly disappeared. Again, the demise of this species has been attributed to hunting and land use practices associated with white settlers (Cowan 1936, Bailey 1936, Scheffer 1940). It is interesting to note, however, that white-tailed deer in the eastern U.S. tend to follow the settlement of range lands. Their populations have been known to increase to nuisance levels when farm fields and livestock feed are raided.

The minor impact of the acquisition of horses and the lack of success of cattle ranching in this area, along with the meager early records of native artiodactyls in the Columbia Plateau suggests that decimation of the large mammals may have begun prior to attempts to introduce domestic livestock into the region. The cause of the decline in artiodactyl populations remains unknown, but it is suggested here that the factors leading to decline in the native artiodactyls may be the same as those that precluded successful cattle ranching in the 19th century. It is possible that the aboriginal grassland prairies that supported the native herds were already declining and unable to support the populations of grazing animals that had previously lived in the Columbia Plateau.

Study of the reduction of white-tailed deer populations in the Southwest has suggested that vegetational changes, livestock overgrazing, and/or rangefire suppression favored mule deer over white-tailed deer (Anthony and Smith 1977). It has also been demonstrated that April-June drought is an important factor affecting the mortality of white-tailed deer while mule deer are better able to exploit fluctuating wet and dry winters and are better adapted to arid conditions (Anthony 1976). Declining white-tailed deer populations in Arizona appear to coincide with incidences of seasonal drought and/or heavy livestock grazing. Population fluctuations may result in extinction of small isolated populations and usurption of vacated habitats by mule deer that are better adapted to the drier conditions. Livestock overgrazing increases the effects of drought by removing herbaceous cover resulting in decreased effectiveness of summer precipitation and increased evapotransporation rates (Cable 1980).

The relative abundance of mountain sheep (Ovis canadensis) decreases through time (Table 12-9) from 18.4% of the total artiodactyls in the Kartar Phase to 12.7% in the Hudnut Phase and 12.1% in the Coyote Creek Phase. They are now extirpated in the project area. The timing and cause of their demise is unknown, but can be fairly narrowly restricted to the late prehistoric-early historic period. Study of recent sheep in Montana has revealed a phenomenon similar to that described above for white-tailed deer: early summer-fall drought has an extremely detrimental effect on lactating ewes and newborn lambs. Valley bottoms and southfacing slopes where the first green forbs appear in the spring were determined to be the most important range in terms of reproductive success for the Montana sheep (Brown 1979). The same may have been true for the project area sheep. Whether their population was decimated by spring/summer droughts or the impact of Euroamericans or both, is impossible to determine. What is apparent is that sheep were at one time not only a subsistence resource, but a stable part of the faunal community in the project area.

Conclusions

There is no clear cut, unequivocal faunal evidence for environmental change in the project area during the period of human occupancy. There are some slight differences in taxonomic composition of the faunal assemblages from various time intervals that appear not to be associated with the size of the recovered samples or other analytical vagaries. Whether these are due to changes in the nature of human exploitation or environmental changes is uncertain. If the changes reflected in the faunal data are a result of changes in environment, they appear not to have been major climatic differences, but perhaps a gradual overall warming or drying trend that may reflect a seasonal shift in the timing of precipitation. Alternatively, they could indicate more localized site-specific changes in the environment such as the river shifting in its bed changing the edaphic environment near a site which would in turn affect the plant and animal populations living in the immediate area. Fire, likewise, could have destroyed a vegetation community that was supporting a faunal community that was contributing elements to a particular archaeological assemblage. Regional, short term, flooding or drought such as occurred in the 1920s could easily decimate a local animal population that had been exploited by humans, resulting in subsistence resource procurement occurring further from the site. A shift in the location of subsistence resource procurement might entail a slight shift in relative abundance of taxa introduced into the site either as a result of differences in animals captured or differential transport of preservable parts to the sites.

The decline in the grassland and riparian vegetation that supported prehistoric animal populations may have begun early in the project area in response to a climatic episode of less effective moisture. Whether the episode was long term and gradual, one major short-term episode, or a series of recurrent episodes cannot be inferred from this data set.

If, in fact, the climate in the Rufus Woods Reservoir was gradually warming and/or drying throughout the period recorded in these archaeological deposits (6000 B.P.-contact) the expected response of the faunal community would be a trend toward taxa with more xeric habitat preferences and a loss of those dependent on reliable mesic habitats. This trend is apparent, if not pronounced, in the Chief Joseph fauna in the increase in _Perognathus_ and _Lagurus_ and the loss of the grazing artiodactyl taxa and those dependent on spring forbs.

SEASONALITY

One of the archaeological issues we had hoped to address with the faunal remains is season of site use. Reconstruction of prehistoric subsistence and settlement patterns often relies on determining the season(s) of the year during which particular sites were occupied. In the site report series a fairly standard approach was taken, with reservations, to seasonal interpretation of the available data. Although the faunal remains can make a major contribution to the reconstruction of seasonal patterns of land use in the project area as initially hoped, the seasonality data are more complex than anticipated and do not allow simple inferences. The large number of analytic zones providing faunal assemblages containing seasonal data provide an opportunity unprecedented in Plateau archaeology to examine some of issues involved in inferring season of site use.

Assumptions

Estimating seasonality of site occupation from faunal data relies on ecological and ethnographic analogy (Monks 1981). Seasonality data indicate the season the animal died; the season the site was used by people is an inference. The assumption that the season of death of animals in an archaeological assemblage indicates the season that people used the site has two potential sources of error. The first involves the question of whether the species used as seasonality indicators were deposited as a result of human activity. In the site report series we have argued that the taxa used to assess seasonality were deposited by cultural mechanisms based on evidence of butchering or burning. A second potential source of error in estimating seasonality concerns whether an animal was killed and eaten immediately or if it was stored and then consumed (Monks 1981). Because there is extensive reference to drying and storing fish in the ethnographic literature (Ray 1932; Post 1938), and because it was generally impossible to identify the species of fish elements, the presence of anadromous fish has not been used here as an indicator of season of site use. Still, we have no way of knowing that fish were in fact stored in the past. Nor can we argue that other taxa used to infer seasonality were not stored.

The seasonal data used include two kinds of indicators. First, if the age at death of seasonally reproducing animals is known, the season the animal died can be calculated, assuming there has been no change over time in the season of birth. Second, the season of human activity can be inferred from the presence of seasonally active taxa using the assumption that animals whose activity patterns are climatically controlled were active and available for capture by people only during the same seasons in the past and were captured only when active. Grayson (1983) and Grayson and Thomas (1983) argued that inferring seasonality on the basis of taxa available during only part of the year is risky at best due not only to the fact that we know that modern communities and populations may not be representative of past communities and populations, but also because seasonal activity in taxa such as migratory waterfowl only shift in abundance from season to season. Only in cases of rare species does a species truly become unavailable. While Grayson and Thomas based their caution on an example of migratory waterfowl, we must acknowledge that the same argument holds true for the taxa that were used in these assemblages: marmots, ground squirrels, and painted turtles. Modern marmots and ground squirrels hibernate and estivate when climatic conditions become too extreme (either too hot or too cold) for their comfort. In extremely mild years they may be active much longer than in years that are very hot or very cold. Further, all identified turtle elements are shell, which may have been curated for tool or ornament manufacture.

The other kind of data considered in suggesting season of site occupation is age at death for individuals of taxa with a known season of birth. Three taxa for which butchering evidence indicated people were the primary agent of deposition were used: deer, sheep, and antelope. Age at death for artiodactyl mandibles was determined by tooth eruption or molar wear (Severinghaus 1949, Robinette et al. 1957, Cowan 1940, Dow and Wright 1962). Determining the age of individuals in this manner has limitations, some of which were discussed in the Research Design (Campbell 1984). For the purposes of this discussion we accept that age determination is valid, but keep in mind there may be an error factor of up to ±3 months for older individuals (see Chaplin and White 1969 for a discussion of this problem).

In addition to the numerous assumptions which must be made to link season of death of individual animals to season of site use, determination of seasonality is subject to the same problems and biases as other kinds of faunal analyses. In particular, sample size and sampling biases play a large role. When only one or a few animals are ageable, season of site occupation appears to be a fairly straight forward inference: the site was apparently used during the season when the animal(s) died, accepting for the sake of argument that no storage occurred. However, as the sample becomes larger, the portion of the year during which it may be inferred that the site was occupied increases, until a point is reached at which it appears the site was occupied year round. At most sites, the shortest indicated span of site occupation occurs in the analytic zones with the smallest samples of seasonal data, evidence of year round site occupation is found in analytic zones with the largest samples of seasonal indicators. Again, as in using seasonally active taxa, it should not be inferred that the site was not occupied during seasons not represented in the faunal assemblage. The absence of indicators of specific seasons may alternatively indicate that the taxa used during those seasons are not seasonally sensitive in an archaeologically visible manner, that they were not introduced into the site, or that they did not preserve (Monks 1981:226).

The appearance of year round occupation in assemblages with large samples of ageable artiodactyls suggests the necessity of a consideration of how the number of seasonality indicators recovered may influence the seasons indicated. Common sense tells us that if a site was occupied for only a short span of the year, only a very small assemblage of bones will have been deposited by people. The shorter amount of time the site was occupied and the fewer bones deposited, the less opportunity there would be for seasonally sensitive material to get deposited. The longer people lived at a site, the more bones would get deposited and consequently the greater the chance of seasonally indicative elements. This is, in fact, the basic principle upon which all seasonality inferences are based. However, the relationship between seasonal indicators, size of a recovered faunal sample and seasonality of site use is not necessarily simple.

Effects of Sample Size

Many factors, such as recovery biases, preservation, nature of the mechanism of deposition, or nature of the population sampled, as well as seasonal site use, may be reflected in the seasonal data recovered. Before attempting to ascertain which factor(s) determined the nature and distribution of any sample of seasonal indicators it is important to recognize that the relationship between seasonal indicators, sample size and annual length of site use is also explainable in statistical terms. The larger the sample of seasonally sensitive elements, the more likely all seasons will be represented. For instance, if we had recovered only the two ageable deer in the Coyote Creek Phase component at 45-OK-258 (Figure 12-5), we have evidence of site use during a maximum of two months, August and October. We might infer that the site was occupied during September due to the inaccuracies in the method, or we might simply say the site was used during late summer-early fall. However, inclusion of the sheep data radically changes the picture. The sheep in this assemblage apparently died in April, May, July, and October. We now have evidence of site use that extends through spring, summer, and early fall. Yet, for only one month is there more than one specimen indicating use of the site during that month. The histogram from the Hudnut

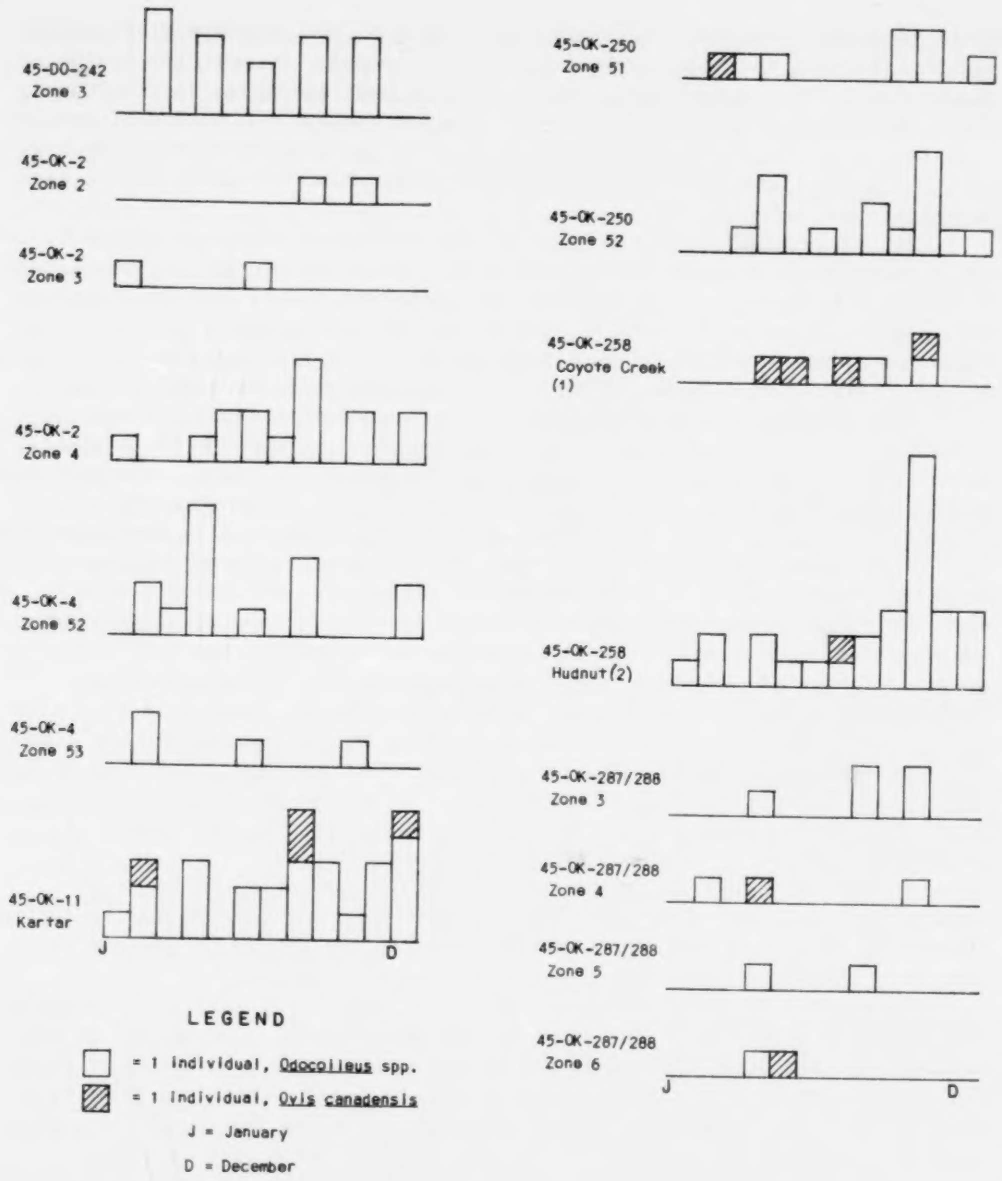

Figure 12-5. Seasonality data summarized by zone (all zones with more than one aged artiodactyl are shown).

Phase component (Figure 12-5) makes the nature of the possible distribution of seasonality data in these assemblages more apparent. In contrast to the Coyote Creek Phase assemblage, the 31 ageable deer mandibles in the Hudnut Phase assemblage at 45-OK-258 indicate site use during all months of the year with the exception of May. There is a peak in the distribution during mid-fall (October). Adding the single ageable sheep does little to change the nature of the distribution.

Considering the effects of size of the sample of seasonal indicators on the estimation of seasonality is not novel. Monks (1981:225) suggested that to assess the reliability of seasonality estimates faunal samples should be evaluated in terms of the reliability of the MNI value upon which they are based using the technique of partitioning the curve defining the relationship of MNI to MNI/NISP (Grayson 1978). It is conceded here that MNI is the measure of abundance from which seasonality assessments should be made to avoid the possibility of concluding there are many indicators for a given season because there are many elements of the same individual. However, size of the total assemblage is not necessarily a concern in determining seasonality, rather it is the number of elements of seasonally sensitive taxa that is at issue. There may be a tight correspondence between the two measures, total sample size and number of seasonally indicative elements. In fact, in these assemblages there is a correlation of $r_s=0.60$ $(0.1>p>0.05)$. However it is conceivable that we could recover an assemblage consisting almost entirely of seasonally sensitive elements, for instance a deposit containing a preponderance of very young birds (Howard 1929) or a kill site (Wheat 1972). Or, we could conceive of a large assemblage containing almost nothing of seasonal importance, for instance an assemblage containing mostly rodents and lagomorphs (e.g. Grayson 1983). In either of these cases the total size of the sample would be irrelevant, but clearly the number of seasonally indicative elements recovered is of interest. It is in this respect that the Chief Joseph faunal data is disappointing in terms of determining season of site use. Even though there are over 25,000 identified specimens, only in a very few analytic zones is the sample of seasonally sensitive specimens large enough to draw firm conclusions.

The effects of the size of the sample of seasonally sensitive elements recovered are apparent in the Chief Joseph faunal data. Comparison of the seasonality data from the Hudnut and Coyote Creek Phase components at 45-OK-258 suggests that it is not possible to make reliable inferences from this kind of data until there are enough specimens to allow the possibility of at least one specimen per portion of the year (months were used in this analysis). When a very large sample of seasonality data is available, such as for the Hudnut Phase component at 45-OK-258, it may be represented as a histogram showing the abundance of animals representing activity at the site for each month. The series of histograms in Figure 12-5 shows the distribution of seasonal data for all sites from which ageable artiodactyls were recovered. This means that for components with small assemblages it is impossible to determine whether seasons represented are the peaks of a relative frequency curve or a random sampling of a more even distribution representing year round occupation. Once a pattern is apparent in the frequency curve, as in the large assemblages (the Hudnut Phase component at 45-OK-258; the Kartar Phase component at 45-OK-11; Zone 2 at 45-OK-4; Zone 2 at 45-OK-250), it may be reasonable to make comparisons of differences seen in the seasonality data. For instance, in the zones listed above, with the exception of Zone 2 at 45-OK-4, artiodactyls were apparently most heavily hunted during the fall. In Zone 2 at 45-OK-4 the most abundant evidence for artiodactyl hunting indicates most of the animals were killed in the spring.

While the distribution of aged artiodactyls may in fact represent seasonal site occupation, it may also reflect seasonal availability of the animals near the site, or seasonal shifts in hunting patterns, (e.g. preference for hunting deer in the fall because they are fatter). Because there is evidence in the seasonality data that most of the sites with many seasonally sensitive elements were occupied year round it is more probable that the higher relative abundance of indicators during given seasons are reflecting either seasonal animal behavior or seasonal hunting behavior than seasonal intensity of site use. The histograms will not permit the determination of cause, they simply display the differences. Determination of why more deer were deposited at 45-OK-4 during the spring than at any of the other sites will have to come from other kinds of evidence.

CONCLUSIONS

This chapter summarized the general nature of faunal materials recovered during salvage excavations at the Chief Joseph Dam Archaeological Project. The primary focus has been on the nature of the assemblage itself, especially the mammalian assemblage. In particular, the discussion above has addressed analytical issues encountered in interpreting these faunal materials as they relate to the interpretation of the environmental and cultural aspects of the sites. While to some the discussion above may seem unduly critical or cautious, the purpose of taking such an approach was to assure that conclusions based on the faunal data are firmly grounded. Thus, while the discussion of the faunal data in this chapter reaches few specific conclusions, it attempts to address the practical aspects of analysis of faunal remains that may clarify the use of the faunal data in other chapters in this volume, and which may relate in a more general way to the use of archaeological faunal data. In general, relating the faunal materials to the cultural assemblages has been left to the other authors of this volume (Salo, Chapter 6; Sammons-Lohse, Chapter 14; and Campbell, Chapter 15).

There are many aspects of this faunal assemblage that have not been investigated due to the constraints of time and resources. Mention was made in the text above of some questions such as the effects of sampling, and skeletal element distribution that are obvious issues that deserve further consideration. There are surely many others, some of which have not occurred to us. One of the primary objectives of presenting this summary is to make the data available with the hope that it may be of interest and use to others concerned with the prehistory of eastern Washington.

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13. BOTANICAL ASSEMBLAGE

by Nancy A. Stenholm

Ethnographic and ethnobotanical literature (Ray 1932; Spier 1938; Teit 1930; Turner 1978, 1979; Turner et al. 1980) documents the use of a large array of botanical materials by native people of the Upper Columbia region and adjacent Okanogan Highlands. Approximately 250 species of native plants were used, about 150 of these for non-medicinal purposes: as food, tools, construction, cordage, dyes, fuel, adhesives, poisons, smoking material, textiles, abrading materials and the like. While wood charcoal is common in archaeological sites on the Plateau, including structural remains in houses and burials, it has not been common practice to identify charcoal taxonomically, or to deliberately recover other sorts of botanical remains. Identified plant materials from previously excavated archaeological sites in the Upper Columbia region include large seeds or nuts recovered by standard excavation screening (Chance and Chance 1982), and manufactured artifacts of wood, cordage, and other plant remains from special preservation situations such as burials (Collier et al. 1942) or rockshelters (Mills and Osborne 1952). The botanical analysis performed for the Chief Joseph Dam Cultural Resources Project represents the first systematic application, to open sites of hunters and gatherers in this region, of the special archaeobotanical recovery methods--water separation and chemical flotation--which have proliferated in the past 15 years (Struever 1968; Watson 1976).

Our results demonstrate a varied floral inventory, indicating a wide range of subsistence activities at housepit and nonhousepite sites in the riverine environment. This is true even though we have been able to deal with only a small percentage of botanical material available in flotation and carbon samples. Fifty-six taxa, representing 42 genera, and 27 species have been identified from 8 sites at the Chief Joseph Dam Project (Table 13-1). These were retrieved from 459 flotation and carbon samples (charcoal collected for radiocarbon dating and other bulk charcoal samples) examined in 20 months of analysis and report writing. An estimated 22,000 individual pieces of charred and semi-charred bits of botanical material were identified from standard subsamples taken from over 200 kg of sediment.

Taxa regularly encountered include 12 conifer species, 13 hardwoods, as well as plants suited for flooring, bedding, and linings for house structures, storage pits and earth ovens (grasses, branches, and bark). The assemblage also includes six plants useful for cordage, basketry, and mat construction (Indian hemp, willow, virgin's bower or clematis, bulrush, ryegrass and cedar

Table 13-1. The botanical assemblage by site (from 451 flotation and carbon samples).

Taxon	45-OK-2/2A	45-OK-11	45-OK-18	45-OK-250	45-OK-258	45-OK-287/288	45-DO-204	45-DO-214
Abies sp. (fir)	x							
Acer sp. (maple)					x			
A. glabrum (Rocky Mountain maple)						x		
A. circinatum (vine maple)								x
Amelanchier alnifolia (serviceberry, saskatoon)	x[2]	x[2]	x[2]	x[2]	x[2]?	x[2]		x
Amelanchier/Crataegus (serviceberry/hawthorne)	x	x			x		x	x
Apocynum sp. (Indian hemp)								x
Artemisia tridentata (sage, big sage)	x	x	x		x	x[2]	x	
Betula sp. (birch)		x		x				
B. occidentalis (western birch)								x
Betula/Alnus (birch/alder)						x		
Camassia sp. (camas, "black" camas)				x				
Celtis douglasii (hackberry)	x		x	x	x			
Chamaecyparis nootkatensis (yellow cedar)	x				x			x
Chenopodium sp. (goosefoot)		x		x	x		x	
C. fremontii (western goosefoot)		x		x	x			
Chrysothamnus nauseosus (rabbitbrush)			x		x	x	x	
Clematis sp. (virgin's bower)	x	x						
Comandra umbellatum (bastard toadflax)						x		
Crataegus sp. (hawthorne)	x	x[1]	x	x[1]		x[2]	x	x[2]
Elymus sp. (ryegrass)		x						
E. cinereus (giant ryegrass)								x
Fragaria sp. (wild strawberry)		x						
Hedeoma sp. (pennyroyal)					x			
Helianthus annuus (common sunflower)	x			x		x		
Holodiscus discolor (oceanspray)				x				x
Juniperus scopulorum (juniper)	x	x			x			
Larix occidentalis (larch)	x	x	x	x	x	x		
Letharia sp. (wolf "moss", lichen)						x?		x?

1. Seeds
2. Wood and seeds
? Identification probable

Table 13-1, cont'd.

Taxon	45-OK-2/2A	45-OK-11	45-OK-18	45-OK-250	45-OK-258	45-OK-287/288	45-DO-204	45-DO-214
Lomatium sp. (biscuitroot, white "camas")	X?	X	X	X	X		X?	X?
Poaceae (grass)	X	X	X	X	X	X	X	X
Panicum sp. (panic grass)		X						
Panicum/Paspalum (panic/paspalum grass)	X							
Phacelia linearis (phacelia)	X						X	
Philadelphus lewisii (mock orange)	X	X		X	X	X		X
Picea sp. (spruce)	X				X			X
Pinus contorta (lodgepole pine)	X	X	X?	X	X			X
P. ponderosa (ponderosa pine)	X	X	X	X	X^2	X	X^2	X
P. ponderosa/P. contorta (yellow pine)	X	X	X	X	X	X	X	X
P. monticola/P. albicaulis (white pine)	X				X	X		X
Plantago patagonica (sagebrush plantain)							X	
Populus sp. (poplar, aspen)	X			X	X			
Polygonum sp. (knotweed, smartweed)						X		X
Prunus sp. (cherry)			X^1	X^1		X^1?		
P. virginiana (chokecherry)	X^1							X^1
Pseudotsuga menziesii (Douglas fir)	X	X	X	X	X	X	X	X
Purshia tridentata (bitterbrush, greasewood)	X	X^2	X^2	X^2	X^2	X^2	X^2	X^2
Rosa sp. (rose)							X^1	
Rhus sp. (sumac)						X		
Salix sp. (willow)	X			X	X	X		
Salix/Populus (willow/poplar)						X		X
Scirpus acutus (bulrush, tule)	X					X^1		
Sporobolus sp. (dropseed grass)			X					
S. cryptandrus (sand dropseed grass)						X		
Taxus brevifolia (yew)	X							X
Thuja plicata (red cedar)	X	X		X?	X	X		X
Tsuga sp. (hemlock)	X	X		X	X			

1 Seeds
2 Wood and seeds
? Identification probable
Table 13-2. Cont'd.

bark), four possible dye plants (wolf "moss", bitterbrush seeds, rabbitbrush flowers, and sunflower hulls), and adhesives (pine, larch, and Douglas fir pitch). Striae on bone and steatite objects indicate use of horsetail (Equisetum sp.) as an abrasive. Edible plants include two roots (Lomatium or white "camas", and black camas), five fruits (serviceberry, hawthorn, chokecherry, rosehips, and strawberry), and four starchy seeds (pine nuts, western goosefoot, common sunflower, and knotweed). Other possibly edible seeds (pennyroyal, shining sumac, and a second goosefoot species) await more specimens for identification. A possibly edible berry (bastard toadflax) completes the list.

Table 13-2 summarizes the contents of flotation samples by phase. It and Table 13-1 are referred to throughout the first section of the chapter, which comprises descriptive information on each taxon or tissue type in the assemblage. This is followed by brief sections considering methodological issues, implications for subsistence practices, and comparisons among phases. It is hoped that discussion of the taxa assemblage and the discussion of problems incurred in the analysis may be helpful for future botanical recovery projects in the Pacific Northwest. For a discussion of the methods employed in field recovery and laboratory analysis, and various problems encountered, see the Research Design (Campbell 1984d). For additional detail on specific botanical items or assemblages, see the individual site reports.

CONIFERS

The wood of nearly every genus of conifer currently found in the State of Washington is found in the samples. Much of the conifer wood must have been transported to the sites as river drift.

Ponderosa pine is the only conifer tree which dots the surfaces of terraces today (Figure 13-1). A few Douglas fir trees with an occasional juniper can be seen on north-facing slopes, and in moist draws. Current visitors to the project's sites would have to walk to elevations of 600 m (1800 feet) to locate a reliable supply of the fir. All three woods are useful as fuel and construction material.

Douglas fir is common in our flotation samples from earliest times, and it shows a slight increase in frequency from 2000 years to the present, the only locally available conifer wood to increase through time. Douglas fir was used both as fuel and for artifacts. Two incomplete manufactured objects of Douglas fir carefully wrapped in birch bark strips were found in a cache of bone, wood, bark and other objects from 45-DO-214 that is about 1100 years old. One appears to have been a beveled wand or piece, rectangular in cross section and about 1.5 mm wide. The second piece is thin, flat with two gently rounded edges at least 18 mm wide by 3.5 mm thick. The function of the objects has not been determined.

It is probable that much of the ponderosa pine and some of the yellow pine (a group composed of ponderosa and lodgepole pines) was used primarily as fuel. Features identified as hearths and other areas of burning usually contain some pine, and the pieces in the samples are usually thoroughly

Table 13-2. The botanical assemblage from 235 flotation samples quantified by phase.

Identified Botanical Material	Karter (N=63)				Hudnut (N=95)				Coyote Creek (N=77)				Total (N=235)	
	g	%	#	%	g	%	#	%	g	%	#	%	g	%
Conifer(62%)														
Lodgepole pine	0.03	2	3	5	0.37	8	17	18	0.12	3	10	13	0.52	30
Ponderosa pine	0.27	20	16	25	0.88	20	32	34	0.22	6	12	16	1.38	60
White pine	–	–	–	–	<0.01	<1	1	1	0.01	<1	2	3	0.01	3
Yellow pine	0.22	16	28	44	0.50	11	43	45	0.22	6	29	34	0.94	100
Douglas fir	0.06	4	10	16	0.19	4	33	35	0.26	7	32	34	0.51	75
Spruce	–	–	–	–	0.02	5	2	2	0.01	<1	1	1	0.03	3
Larch	0.05	4	10	16	0.18	4	17	18	0.04	1	5	7	0.27	32
Hemlock	<0.01	<1	1	2	0.02	5	6	6	0.03	1	4	5	0.05	11
Pinaceae	0.03	2	8	13	0.11	3	13	14	0.04	1	11	14	0.18	32
All Pinaceae	0.66	48			2.28	53			0.95	26			3.89	
Red cedar	–	–	–	–	0.01	<1	4	4	0.16	4	13	17	0.17	17
Yellow cedar	–	–	–	–	–	–	–	–	0.03	1	2	3	0.03	2
Juniper	<0.01	<1	2	3	0.02	<1	6	6	0.04	<1	4	5	0.06	12
Cupressaceae	–	–	–	–	0.01	<1	2	2	0.07	2	10	13	0.08	12
All Cupressaceae	<0.01	<1			0.04	1			0.30	8			0.34	
Yew	–	–	–	–	–	–	–	–	0.10	3	8	10	0.10	8
Bark	0.03	2	18	29	0.31	7	49	52	0.09	2	11	14	0.43	78
Cone	0.28	20	3	5	0.06	1	18	19	0.03	1	3	4	0.37	24
Pitch	0.03	2	14	22	0.04	1	15	16	0.01	<1	5	7	0.08	34
Other conifer	0.09	6	16	25	0.21	5	25	26	0.30	8	36	47	0.60	77
All Conifer	1.08	79			2.84	67			1.78	48			5.81	
Hardwood (24%)														
Sage	<0.01	<1	2	3	0.16	4	14	15	0.28	8	18	23	0.44	34
Rabbitbrush	–	–	–	–	0.01	<1	1	<1	0.02	1	2	3	0.03	3
All Asteraceae	<0.01	<1			0.17	4			0.30	8			0.47	
Serviceberry	<0.01	<1	1	2	<0.01	<1	5	5	0.05	1	5	7	0.05	11
Hawthorn	–	–	–	–	–	–	–	–	0.04	1	2	3	0.04	2
Serviceberry/ hawthorn	0.01	1	4	6	0.14	3	13	14	0.08	2	11	14	0.21	28
Oceanspray	–	–	–	–	–	–	–	–	0.01	<1	2	3	0.01	2
Bitterbrush	0.03	2	11	18	0.56	13	39	59	0.40	11	23	30	0.99	63
Rosaceae	0.01	1	5	8	0.02	1	10	11	0.01	<1	8	10	0.04	23
All Rosaceae	0.05	4			0.72	16			0.57	15			1.34	

Table 13-2, cont'd.

Identified Botanical Material	Kartar (N=63)				Hudnut (N=95)				Coyote Creek (N=77)				Total (N=235)	
	g	%	#	%	g	%	#	%	g	%	#	%	g	%
Hardwood (Cont'd.)														
Poplar/Aspen	–	–	–	–	0.01	<1	2	2	<0.01	<1	1	1	0.01	3
Willow	–	–	–	–	<0.01	<1	1	1	0.07	2	2	3	0.07	3
Willow/Poplar	–	–	–	–	<0.01	<1	3	3	<0.01	<1	1	1	<0.01	4
All Salicaceae	–	–	–	–	0.01	<1	–	–	0.07	2	–	–	0.08	–
Maple	–	–	–	–	<0.01	<1	1	1	–	–	–	–	<0.01	1
Birch	<0.01	<1	1	2	<0.01	<1	2	2	–	–	–	–	<0.01	3
Birch/Alder	–	–	–	–	–	–	–	–	<0.01	<1	1	1	<0.01	1
Hackberry	–	–	–	–	<0.01	<1	1	1	0.02	1	3	4	0.02	4
Mock orange	<0.01	<1	1	2	0.04	1	3	3	0.29	8	4	5	0.33	8
Bark	<0.01[1]	<1	3	5	<0.01[1]	<1	7	7	<0.01	<1	1	1	<0.01	11
Clematis	–	–	–	–	–	–	–	–	0.01	<1	1	1	0.01	1
Other hardwood	–	–	–	–	0.04	1	7	7	0.02	1	12	16	0.06	19
All Hardwood	0.05	4			0.98	22			1.28	35			2.31	
Edible Material (3%)														
Seeds	0.04	3	8	13	0.07	2	23	24	0.06	2	13	17	0.17	44
Root	0.01	1	7	11	0.02	1	10	11	<0.01	<1	2	3	0.03	19
Other	<0.01	<1	1	2	0.03	1	9	10	0.01	<1	4	5	0.04	14
All Edible	0.05	4			0.12	3			0.07	2			0.24	
Other Tissue (11%)														
Seeds	0.05	4	7	11	0.14	3	21	22	0.12	3	27	35	0.31	55
Grass	<0.01	<1	4	6	<0.01	<1	6	6	0.06	3	15	20	0.06	25
Leaf	–	–	–	–	<0.01	<1	1	1	<0.01	<1	6	8	<0.01	7
Fiber	–	–	–	–	0.01	<1	8	8	<0.01	<1	2	3	0.01	10
Herbaceous stem	0.10	7	34	54	0.10	2	36	38	0.07	2	16	21	0.27	86
Nonwoody other	0.04	3	20	32	0.09	2	20	21	0.31[2]	8	38	49	0.44	78
All Other	0.19	13			0.34	8			0.56	15			1.05	
Total	1.38				4.38				3.69				9.45	

1. Birch bark in one sample.
2. 0.10 g consists of lichen tissue.

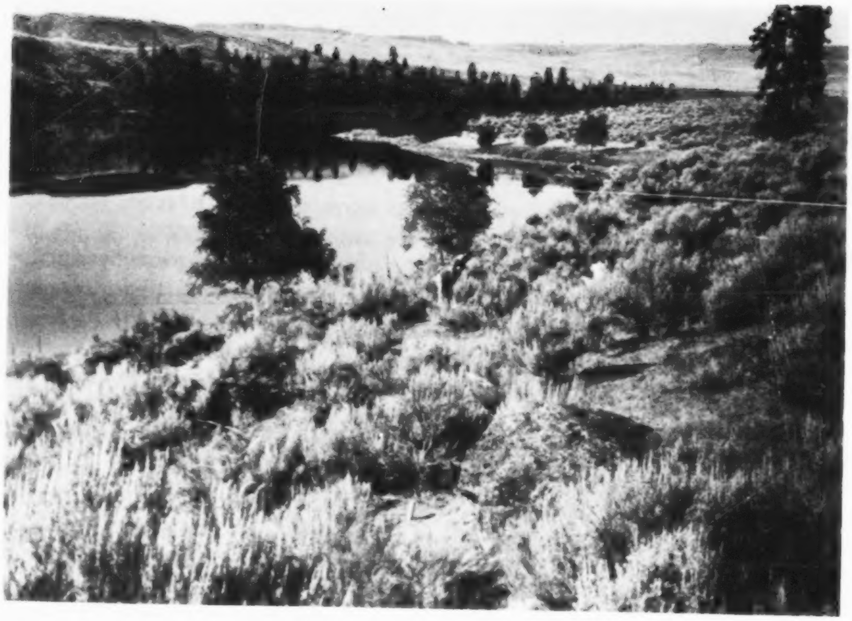

Figure 13-1. Typical vegetation association, 45-OK-258. Ponderosa pine on terrace (upper right); Douglas fir with pine (downstream, north-facing slope); big sage and rabbitbrush (foreground); hackberry trees. Bitterbrush is behind camera.

charred. Pine artifacts were found at three sites. The most complete is a knife-like object wrapped in birch bark from the 45-DO-214 cache that contained the Douglas fir artifacts. Two other objects, from flotation samples, are fragmentary. In both cases, enough of the object is present to show that the pine was cut and smoothed before a thick coating of pitch or resin was uniformly applied to the surfaces. The older example is from a house floor approximately 1100 years old at 45-OK-2 and the more recent is from surface levels at 45-OK-258.

The yellow pine category is made up of branch material, indicating that it was probably collected for fuel as branches are the easiest part of a tree to collect without iron tools. The amount of yellow pine gradually decreases over time (Table 13-2). During the Coyote Creek Phase, ponderosa and lodgepole pine branches still are found in hearths with other conifer species, but their predominance by weight has shifted in favor of more xeric steppe shrubs (sage, bitterbrush and perhaps mock orange).

Larch, common today at elevations over 600 m is another probable fuel species. It is found in moderate quantities in the Kartar Phase and decreases over time, much like the yellow pines. The literature mentions larch as fuel, but rarely as artifactual material. Portions of a pointed larch object at least 10 mm long was found in house debris from 45-OK-2 in the same general area as a resin coated pine artifact (see above) and two examples of twisted cordage or sinew (discussed below under Other).

Spruce (Picea sp.) and true fir (Abies sp.) occasionally are found in samples. True fir has been found in some flotation samples not included in Table 13-2 because of dating problems. All fragments of both trees from flotation samples and carbon samples are mature bole wood, and very little of it is completely charred. Both trees can be considered locally available to some sites in the reservoir. They would take considerable effort to harvest in the wild today, however, because they grow above 900 m (3000 ft) in the Disautel Pass/Summit Lake area. The nearest specimens of Engelmann spruce and Subalpine fir are over 16 km (10 miles) from the lake shore. The largest amounts of the woods were uncovered from a burned structure at 45-OK-2 radiocarbon dated around 800 B.P. (Structure N). The woods were structural members, planking or split lumber, from the sides and roof.

Hemlock (Tsuga cf. heterophylla) is present in all phases as mature wood and rarely is carbonized, resembling red cedar, yellow cedar and spruce in this respect. The largest single amount identified was structural material from Structure N at 45-OK-2. Hemlock is one of the more "exotic" plants in the assemblage. No hemlock has been observed growing on the Colville Reservation in three years of monitering the vegetation. The pollen record from Goose Lake (see Dalan; Nickmann and Leopold, this volume) shows no appreciable hemlock in the area for the past 12,000 years. It is probable that the trees came down river from Canada in recent times. Although the tree was a valued construction and artifact material along the Northwest Coast (Turner 1979:113-116), it is rarely mentioned in the ethnobotanical literature of our region.

Red cedar (Thuja plicata) makes its first appearance during the Hudnut Phase and gradually increases in our flotation samples. Most of the cedar in the assemblage is from features associated with housepit debris and other kinds of structures. It is rarely fully charred in flotation and carbon samples, suggesting that the wood was not often used for fuel. Red cedar is found at elevations similar to that of spruce and true fir but the closest stand is at North Twin Lake, 56 km (36 miles) east of the mouth of the Nespelem River.

A few manufactured objects of red cedar have been recovered from features at 45-OK-2, 45-OK-288, and 45-DO-214. A worn plank from a housepit floor at 45-OK-288 and a thin spatulate object associated with a cache and hearth from 45-DO-214 are securely dated between 1200 and 1100 B.P. At least three split planks formed part of the super-structure of Structure N at 45-OK-2, dated to about 800 B.P.

Flotation samples from Structure N also contained split and processed bark. The oldest cedar bark (red or yellow) is from housepit matrix from 45-OK-250 with a radiocarbon date of 3100 years B.P. More recent bark was retrieved from Housepit 3, 45-OK-2. Mills and Osborne report cedar bark cordage and part of a cedar bow in an undated rockshelter in the Upper Grand Coulee near Electric City (1952:355). Projectile points found with the materials are fairly recent, probably Coyote Creek Phase in age.

Ethnographic sources (Ray 1932) note that cedar logs were pulled from the river in pre-dam times and made into a variety of items. Some of these artifacts--canoes, paddles, floats, net gauges, and splints for salmon-drying--are associated with river-oriented activities where lightness, ease of working, and resistance to warp and decay might be important. Other artifacts are more "hearth or home" oriented such as sticks used for stirring stews, planks and boards used for food platters and house construction, and bark for containers (Post 1938:15,19,32; Post and Commons 1938:39,41,53,57,60; Teit 1930:222-223). Cedar is mentioned as often as any wood in the ethnographic literature, which is rather surprising given its natural distibution. Still, waterborne logs must have floated down the Columbia River fairly frequently in pre-dam times. A local resident recalled that one person made cedar fence posts from snagged logs as a small cottage industry (Thallheimer, personal communication, 1983). Red cedar logs float high in the water and are easy to spot from the shore. Yellow cedar (Chamaecyparis nootkaensis), which is found in Coyote Creek Phase flotation samples, are not as buoyant but the wood has about the same working properties as red cedar. Both cedars may have been sought in the same manner. Both red and yellow cedar logs with bark have been noted among wood taken from the river above Grand Coulee Dam patrol boats. Yellow cedar is another exotic species, probably arriving by water from Canada. According to Teit, the Sanpoil claimed that "good" basketry material was scarce, and that they collected cedar, spruce and juniper roots from river drift (1930:223).

Another valuable wood, yew, was found only in Coyote Creek Phase assemblages. The source of yew is not known. It is possibly from Canada and may have been traded (Turner 1979:117-118). None of the examples of yew appear to have been worked, and little of it is charred. The oldest securely dated pieces are from Feature 5 at 45-DO-214, dated around 1150 B.P., and from Structure N at 45-OK-2, dated around 800 B.P.

The frequency of nonwoody conifer materials such as bark and cone fragments in flotation samples decreases over time. This may simply reflect the general decrease in pine family members in the samples, since most of these categories are Pinaceae taxa. Most of the cones are pistillate but two staminate cones have been identified. The oldest pistillate cone fragments are of ponderosa pine found with a small quantity of seeds, dated to about 4500 B.P. at 45-DO-204. A hearth about 6000 years old with some cone material and about 200 seeds, possibly representing a meal, was found at the same site. Two other seeds have been found in a Hudnut Phase feature from a house floor with a date of around 2900 B.P. The seeds were found in the same flotation samples as lomatium tissue.

We have good indications that pitch or resin was an important adhesive and preservative in the past. The two pitch-coated objects of pine wood discussed above were carefully dipped or painted with melted pitch. Indian hemp fibers (Apocynum sp.) embedded in pitch were found in the cache at 45-DO-214 which also included birch bark strips welded in pitch. Use of pine family resin is well documented in the literature (Post and Commons 1938:53,56; Ray 1932:88-89; Turner 1979:108, 112, 116). Other adhesives--fish glue and birch bark resin--were available in the environment but pine pitch would have been easily obtainable year around.

Finally several ponderosa seeds and one spruce needle have been identified in flotation samples from four sites. The oldest pine needle is from a structure at 45-OK-250 with a date of 3200 B.P. More recent examples are from flotation samples from 45-OK-2A and 45-DO-214. A portion of a spruce needle was identified from recent, possibly historic levels from 45-DO-204.

In sum, the conifer category is very well represented in the Rufus Woods Reservoir sites. A number of relatively exotic taxa are found in the flotation and carbon samples, and preservation of the woods is generally good. The relative proportion of conifer taxa decrease over time, with a few notable exceptions, as the number of taxa increases. As we shall see, the opposite is true of certain hardwood groups.

HARDWOODS

Hardwood taxa constitute 24% of the assemblage weight. Nearly all the hardwoods present in our asssemblage can be found within walking distance (5 km) of most sites in the Reservoir. There seems to be less use of more distant taxa than discussed above for conifer species. Some such as big sage (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus nauseosus*), bitterbrush (*Purshia tridentata*), hackberry (*Celtis douglasii*), serviceberry (*Amelanchier alnifolia*), and black hawthorn (*Crataegus douglasii*) can be found on terraces and rocky slopes today. Willow thickets (*Salix* spp.) though a bit rare now because of recent waterlevel rises, were probably common at the river's edge. Quaking aspen (*Populus tremuloides*) can often be seen in draw bottoms and sometimes in protected spots on hillsides. Even more mesic hardwoods which often attain tree status such as maple, birch, and black cottonwood (*Populus trichocarpa*) are a few hour's walk away above 600 m in the Okanogan Highlands. The most exotic hardwood is oceanspray (*Holodiscus discolor*), found under mixed coniferous cover above 700 m. Thus none of the hardwoods found in flotation and carbon samples would be difficult to obtain on fairly short notice from living specimens. In contrast to the conifers, probably more than a dozen hardwoods available in the area were ignored or little used. Apparently the prehistoric inhabitants actively sought all the conifers available to them by river or other means and were more casual about the potential hardwoods available through the same means.

The most common hardwoods in the assemblage are those which often grow on the sites today--bitterbrush, sage, mock orange, serviceberry, and hawthorn. Bitterbrush is clearly the most important hardwood in weight and number of appearances. Bitterbrush seeds (discussed in detail under Nonedible Seeds) are found more often than any other kind. Bitterbrush charcoal is second only to ponderosa pine in assemblage weight, and appears more often (if we could divide the yellow pine taxon more accurately this likely would not be the case). All but one or two examples of bitterbrush are completely charred. No artifacts of this wood have been identified, nor does the ethnobotanical literature mention the wood for use other than as fuel (Turner et al.

1980:79). We believe that bitterbrush was a major fuel plant, like some members of the pine family. Further, since sage wood is friable and there is no mention of the wood as construction material for tools, and other items, we believe that sage was another fuel species. These two taxa increase over time, just as the more local members of the pine family decrease.

The case for mock orange (Philadelphus lewisii) is less clear. It is not mentioned as fuel in the literature, yet it was used in a hearth at 45-OK-287 during Coyote Creek times. It increases in frequency through time (Table 13-2). The bushes are numerous locally. Mock orange is mentioned as arrow shaft and bow wood as well as material for other tools (Ray 1932:88,89; Turner et al. 1980:108); thus the wood may serve more than one purpose.

Serviceberry, hawthorn, (counted as a combined category, serv/haw) are important plants in the assemblage and in the ethnographic literature. Serviceberry is hard and durable, suited for digging sticks, arrow shafts, seed beater frames, cooking implements and the like (Ray 1932:98; Post and Commons 1938:53,58,60) and the fruits were collected. Hawthorn wood was used for digging sticks, mauls, and wedges and, the fruits were collected in the fall (Turner 1979:234; Turner et al. 1980:125). Both woods are present in our earliest flotation samples. Serviceberry and hawthorn fruits are discussed under Edible Seeds.

Willow and hackberry wood comprise the largest categories among the remaining hardwoods present in the assemblage. Maple, poplar or aspen, birch and oceanspray are present in very small amounts in the flotation samples. All hardwoods except hackberry are amply documented in the enthnographic and ethnobotanical literature as useful tool and construction material (Post 1938; Ray 1932; Turner 1978, 1979; Turner et al. 1980). We have, however, only two objects of these woods which show signs of manufacture, both from radiocarbon samples. A section of cut and smoothed oceanspray wood was found in the 1100 year old cache at 45-DO-214. Although broken and burned, it resembles the bow described by Ray (1932:87-88) in form and dimensions. A large section of willow mainstem, probably used as a structural member, was found in Structure N at 45-OK-2.

The hardwood bark category is comprised of a few pieces of bark of birch, clematis or virgin's bower, willow or aspen, sage, and bitterbrush, as well as many fragments which could not be identified.

Birch bark is more common than birch wood in our sites. The oldest archeological birch bark, approximately 3500 years old, is from 45-OK-11. The oldest culturally processed birch bark is from an 1100 year old cache of objects at 45-DO-214. The bark had been cut and torn into strips 0.6 to 0.7 mm wide and woven to form a covering or sheath around flat pieces of pine and Douglas fir. The function of the composite artifact has not been determined. Chance and Chance note that birch bark rolls were common at Kettle Falls and suggest that some may have been used for illumination and for transferring fire from hearths (1982:113-118). At least one partially charred roll which could have had this function was found in a 3000 year old refuse pit from 45-OK-250.

Clematis or virgin's bower is a rambling vine common to talus slopes and draws. Pieces of bark, too small to identify presence or absence of manufacture were found at 45-OK-2 and 45-OK-11. The oldest pieces are 1100 years old. Clematis was a valuable weaving material for bags, mats, and garments (Ray 1932:45; Turner 1979:227-228). It could also function as tinder.

EDIBLE SEEDS AND TISSUES

While we cannot determine whether fruit seeds, starchy seeds, fruity tissue and root material were from products actually eaten, we believe that most of the taxa described in this section were collected as edibles. Their context suggests this connection. Many are from occupation debris in well-defined hearth and pit features, and most are associated with other plant or animal edible tissues. The edible array comprises approximately 3% of the assemblage by weight, and is found in one third of the flotation samples. The actual number of seeds is small, and root and fruity tissue are only found in 14% of the samples. Except for goosefoot and pine nuts, samples rarely contain more than one seed. The edible assemblage in all three phases is varied and makes up a constant proportion of the entire assemblage. We gained the impression that prehistoric cooks and hearth-tenders used vegetable foods efficiently and were fairly neat in hearth-related tasks inside structures.

SEEDS

Serviceberry seeds appear in six sites, and the oldest examples are approximately 5000 years old from Kartar Phase debris at 45-OK-11. Two others were identified from debris in two post holes (Feature 122 and 133) associated with the floor of Housepit 1 at 45-OK-250, dated around 3000 B.P. The edible plant assemblage from the floor include black camas (Camassia sp.), compressed cakelike tissue probably made from biscuitroot (Lomatium sp.), western goosefoot seeds, a second goosefoot species and charred fruit tissue. The entire edible assemblage resembles the leavings from winter meals of stored roots and fruits.

Seasonality data gathered in the last three years show that prime serviceberries are available in late June on river terraces and in lower draws. The harvest season is over by the end of July, although the fruits may be gathered at higher elevations into August. Women not otherwise occupied in fish-drying activities went on berrying expeditions that varied from one to several days in length (Post 1938:25; Ray 1932:10). The "best kind" of serviceberries (Turner et al. 1980:120-123) in the Reservoir are not found in pure stands. One has to search for them among bushes with fruits considered less desirable. Two kinds of serviceberries are shown in Figure 13-2.

Serviceberries were dried whole, mashed into cakes, and dried or pulverized to make salmon pemmican (Ray 1932:101). They were often mixed with other foods such as bitter-root or salmon eggs. Samples formed into cakes and dried in the sun loose 72% of their moisture content and remain pliant and

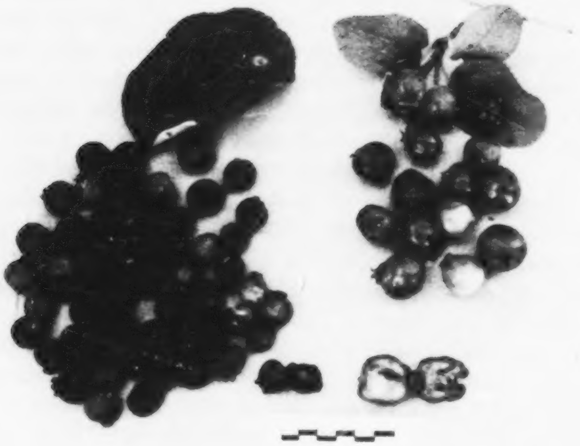

Figure 13-2. Serviceberries from the Nespelem River. The "very best" kind (left), and "second" or "third best" kind (right).

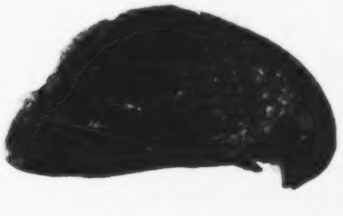

Figure 13-3. Charred serviceberry seed from 45-OK-258. Length of the seed, 3.6 mm; width 1.9 mm.

tasty after a year of storage. We have not found conclusive evidence of serviceberry cakes in the flotation samples, probably because of screening; however, a crushed seed was found with probable lomatium root in a hearth or oven at 45-OK-2A. The presence of charred fruit tissue that resembles serviceberry or chokecherry is rather common in the assemblage (in the "Other" category under Edible Material, Table 13-2). A seed from the very best variety was found in house debris from 45-OK-288 (Figure 13-3). It may be that selection for the best fruits was practiced at least 1200 years B.P.

Hawthorn seed fragments have been found at four sites. The oldest is from pre-housepit and Upper Housepit 1 layers at 45-OK-11 dating approximately 5000±4500 B.P. at 45-OK-11. More recent fragments were identified from occupation debris from 45-OK-288 (Feature A, around 1100 B.P.) and 45-DO-214 (Structure 1, 1000-1150 B.P.). None of these rugged seeds was found entire, which suggests that they had been crushed. Other less rugged material such as serviceberry seeds were found in some of the same deposits and were entire despite their more delicate structure. Chance and Chance report hawthorn seeds from Kettle Falls, but they do not report the condition of the seeds (1982:119). Use seems widespread.

Hawthorn seeds present certain difficulties for the consumer. Haws for instance, can have five 8 mm long nutlets in each small apple-like fruit. They are difficult to remove by hand, and one method to improve edibility practiced across North America is to pound the fruits to a pulp. This method improves palatability, and also insures few seeds survive the treatment.

Turner and others report that the fruits were not regarded highly (Turner et al. 1980:123-124), yet many groups stored the fruits in a variety of ways--dried, pounded into cakes, and mixed with dried meats or other foods. It is curious that something described as "dry" or "tastless" by natives themselves should have been saved. Seeking explanation, we ate fresh haws of every size and color, hoping to discover a superior variety as in the case of serviceberries. Although some had smaller seeds than others, the reports of their unpatatability seemed accurate. We eventually grew to like haws after we found that they improved with age. The persistent fruits that remained on the tree until the first frosts in September became sweet and chewy. At this time the seeds could be chewed and were no more bothersome than grape seeds in raisins. In short, haws may be picked in August, but they become more palatable later and would be good fall or early winter food, eaten out of hand.

In the case of both serviceberry and hawthorn fruits, the means of preparation may affect their archaeological preservation. Food preparation techniques which feature crushing or pounding of these fruits to form cakes will reduce seeds to small fragments difficult to identify. This may be why both categories are represented by only nine examples each.

The edible category also includes about a dozen wild chokecherries from five sites. Ten of the cherry pits are entire or nearly so, and were picked from site sediments by excavators. The oldest cherry pits are from matrix surrounding a 3500 year old structure from 45-OK-250 and from occupation debris of approximately the same age at 45-OK-18. The most complete specimens with charred flesh were taken from the floor of a burnt structure from 45-OK-2; from occupation debris associated with a hearth and cache from 45-DO-214; and from the floor of a housepit at 45-OK-288. These cherry pits range in age from 1100 to about 800 B.P. All chokeberry pits and pit fragments except those found at 45-OK-2 were found with other kinds of edible tissue from the same flotation sample or from unit levels adjacent to those containing the chokecherries. Cherry fragments have been found with lomatium tissue, sunflower seeds, knotweed seeds, and goosefoot seeds.

According to Post, chokecherry fruits were gathered in mid-August and often were treated like serviceberries, dried on mats and stored whole. Alternatively, they could be pounded with salmon by-products such as heads, tails or eggs (1938:28). Ray notes that chokecherries were used fresh, and that unseeded, mashed fruits were mixed with pulverized, dried salmon and stored (1932:101). Turner reports similar treatment except she does not mention seed removal (Turner et al. 1980:127-128).

In 1980-1983 the chokecherries ripened in mid-August. The best source for these fruits is in draws where they grow in profusion along creek beds (Figure 13-4). Harvest experiments in the lower Nespelem canyon show that over one kg of chokecherries (approximately 1500 ripe fruits) can be stripped by hand from bushes in 15 minutes. The individual fruits are small, measure under 10 mm in their largest dimension, and weigh between 4.0 and 4.5 g. The pits are ovoid, hard and durable and comprise about 18% of the fresh weight of individual fruits (Figure 13-5). They are large enough to be easily seen by excavators when entire. Chance and Chance note that chokecherries are common at Kettle Falls and suggest that they may have been collected there as a salmon additive (1982:118). Chokecherries were also found in an Upper Grand Coulee rockshelter (Mills and Osborne 1952:352). Apparently these fruits have a long history of use in our area.

The Rufus Woods assemblage includes seeds of other fruits, including wild strawberry, rosehip, shining sumac, pennyroyal and toadflax. All but strawberry grow in the immediate vicinity of sites. Strawberry may be considered our most "exotic" fruit as it currently grows under coniferous cover at higher elevations. It is also the most ancient potential food remain in our samples. A complete charred achene was identified from pre-housepit deposits at 45-OK-11. It is probably older than 5000 years. Other seeds--sumac and toadflax from 45-OK-288, and rose seed from 45-OK-204--are more recent, less than 600 years old. Sumac, rosehips, and pennyroyal can be made into infusions, and toadflax can be consumed as a casual nibble (Turner 1978: 215; Turner et al. 1980:131). Since these potential edibles are represented by one seed each, caution must be used in treating them as part of the prehistoric diet until more remains are found.

Starchy seeds found in our assemblage include the common sunflower (Helianthus annuus), goosefoot or lamb's quarters (Chenopodium spp.) and knotweed (Polygonum sp.).

Charred sunflower seed fragments (Figures 13-6 and 13-7) have been found at three sites (45-OK-2, 45-OK-250 and 45-OK-288) in securely dated features inside housepits. The oldest is from a refuse pit at 45-OK-250 with a date of

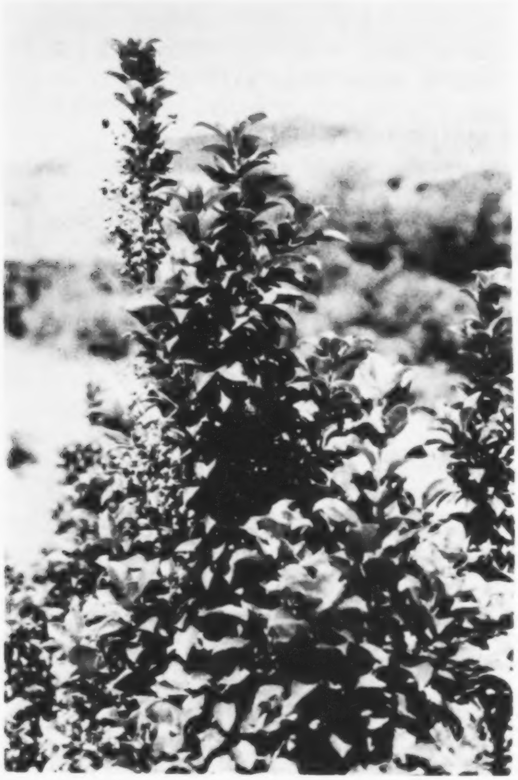

Figure 13-4. Wild chokecherry (Prunus virginiana). Ripe cherries are 8.5-9.0 mm in diameter and weigh 4.0-4.3 g.

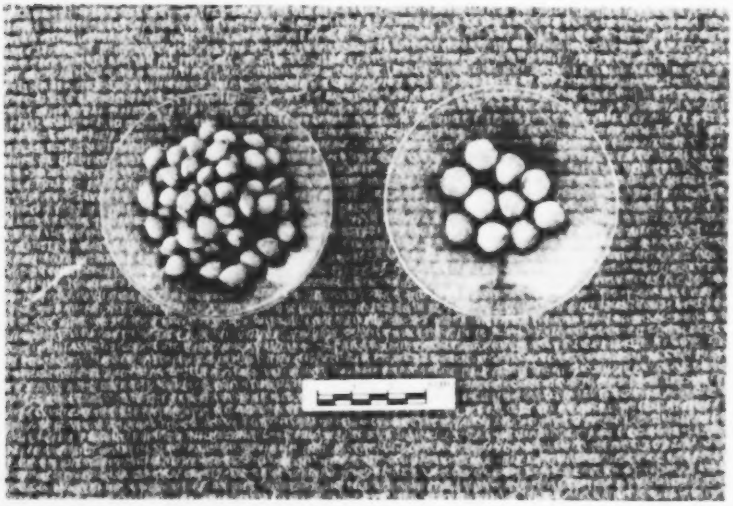

Figure 13-5. Chokecherry pits (left) comprise 18% of the fresh weight, while modern Bing cherry pits (right) comprise 42% of the weight.

Figure 13-6. Partial sunflower achene (left) from 45-OK-288 with charred modern sunflower (right). Charring has exposed fiber bundles. Archaeological specimen is 1.8 mm long and 1.6 mm wide.

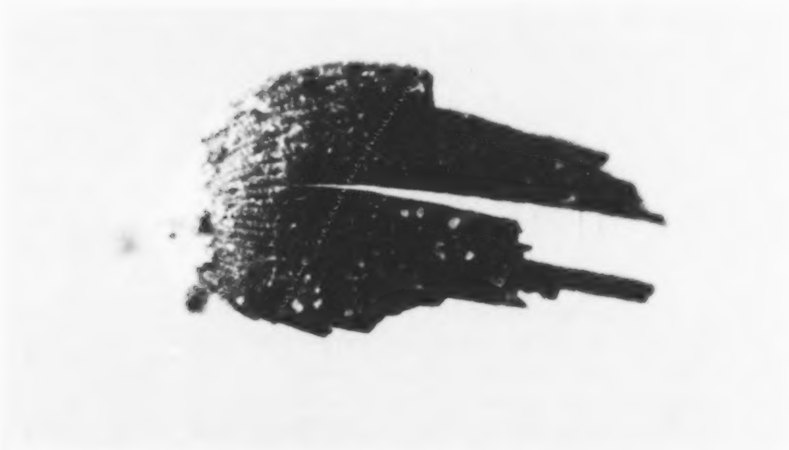

Figure 13-7. Partial sunflower achene from 45-OK-2 showing prominent fiber bundles. Length of fragment 3.0 mm, width 1.7 mm.

approximately 3300 years B.P. Three other seeds were extracted from samples with other edible materials. It is highly unlikely that the seeds were accidentally introduced from modern or historic levels. We mention this fact because the common sunflower is often described as an introduced species and not one collected by Indians in our region (Turner et al. 1980: 80). The Sanpoil-Nespelem Indians collected seeds from the spring sunflower (_Balsamorhiza sagittata_) in early summer (Post 1938:6; Turner 1978:115-119). But none of these valuable seeds have been found in our flotation samples. Our specimens fall within the range of _H. annuus lenticularis_, a showy ruderal sunflower that graces our roadsides from August through September. Seeds are ripe in September, and are a good fall season indicator.

Charred goosefoot seeds from four sites range in age from 3300 to 600 years B.P. At least two species are represented, western goosefoot (_Chenopodium fremontii_) and a smaller seeded species which may be common goosefoot (_C. album_).

Nearly all of the 66 western goosefoot seeds are from securely dated features such as hearths, post holes, and house floor debris. A concentration from 45-OK-258 took us by surprise because the ethnographic literature was mute concerning goosefoot seed collection on the Plateau. The seeds are of particular significance because chenopods were an important wild and cultivated pre-Columbian food in parts of South, Central, and North America (Asch and Asch 1977, 1978; Simmonds 1965). Popped seeds (_C. bushianum_ mostly) have been found in quantity in archeological sites dating to the first millenium B.C. in the Midwest and South (Asch and Asch 1977:35). Our seed concentration is at least as old as these; a radiocarbon sample from the bottom of the oven was dated to 2763±235 B.P. (TX-2905). A minimum of 55 seeds taken from 1.6 kg of sediment is large in comparison to published figures from cache and midden accumulations in portions of eastern North America (Asch and Asch 1977: 35, 1978:331-333). The position of the charred and popped seeds (Figure 13-8) in the middle portion of the oven at 45-OK-258 with mussel shell, fish and other bone indicate deliberate placement. No chenopod stems were found, suggesting that the seeds placed in the feature were detached.

Single western goosefoot achenes have been found in other features at 45-OK-11 and 45-OK-250. None of these examples are younger than 2600 years old, and, most are more than 3000 years old.

The oldest goosefoot seeds (as well as the most recent) are those of a smaller species, which we tentatively have identified as the common goosefoot, _C. album_. Three from housepit features at 45-OK-11 are approximately 5000 years old. Seven others from 45-OK-250 and 45-OK-258 are approximately 3000 years old. The most recent seeds are 1100 and 600 years old. The species identification is provisional pending future finds and confirmation. _Chenopodium album_ is a controversial plant in archeological sites in North America. It is known from sites in northern Europe (Renfrew 1973), but its presence in the New World has not been satisfactorily demonstrated (Fernald 1970; Turner et al. 1980:96) or refuted (Yarnell 1964:92-93).

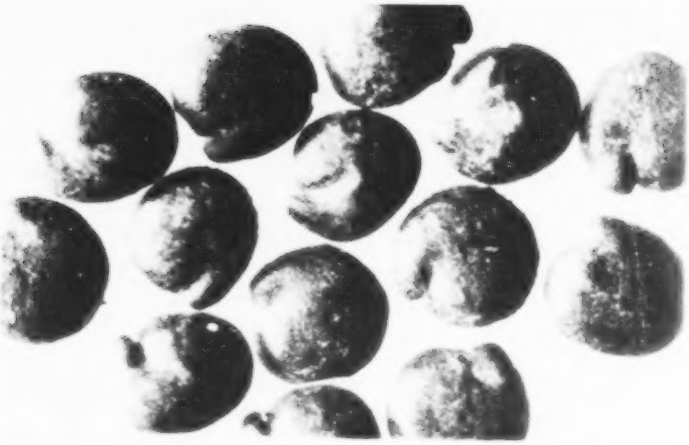

Figure 13-8. Charred goosefoot seeds (Chenopodium fremontii) from concentration at 45-OK-258. Seeds 1.1 to 1.2 mm across.

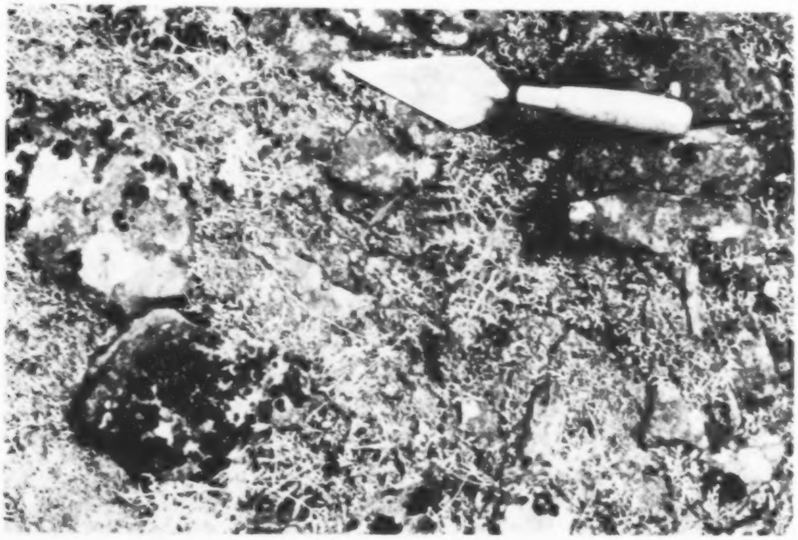

Figure 13-9. Growth habit of Lomatium macrocarpum in Douglas County lithosol. Note low-growing divided leaves (below trowel).

Another starchy seed, knotweed (Polygonum sp.) is a possible edible species. Three examples are from securely dated features. They were found in the same flotation sample as the sunflower seeds at 45-OK-288, in housepit debris from 45-OK-2, and from a hearth from 45-DO-214. All specimens were fragmentary and no species determination was attempted. The seeds are approximately 1200-1100 years old.

Knotweeds (like chenopods and fall sunflower) tend to be weedy, and their presence at sites may be accidental. However, knotweeds are not uncommon in sites in the Midwest, and it has been suggested that one species (P. erectum) was gathered for food and may have been under incipient cultivation (Asch and Asch 1978:330). Our specimens are probably not those of Polygonum erectum, but it is interesting to note that our seeds were found in the same flotation samples as the sunflower, or from flotation samples adjacent to those containing goosefoot. Goosefoot and sunflower ripen at the same time in the fall. We do not know what species of knotweed is represented; however, knotweed generally tends to ripen in late summer.

Grass seeds are not uncommon in flotation samples. Several representing the genus Agropyron or Elymus have been found in occupation debris from structures from 45-OK-2, 45-OK-11 and 45-OK-258. Ryegrass seed (Elymus sp.) found at Kettle Falls was possibly used for food (Chance and Chance 1982:118). Our specimens are complete with glumes (the chaffy covering surrounding the seed) which suggests the seeds were not threshed or prepared before they were charred. The seeds may have accompanied grass stems and leaves brought into the structures in the fall as lining material for floors or pits.

Two fragmentary seeds are tentatively identified as species not expected to occur in project assemblages. A seed fragment from recent levels at 45-OK-2 appears to be wild grape, a plant which the author has not observed in the western half of the Colville Reservation. A charred seed from 45-OK-288 is tentatively identified as mallow (Malvus spp.), a taxon believed to have been introduced from Europe in historic times. The fragment was found in a sample from Feature 7, an occupation surface with radiocarbon dates of 4525±126 and 4641± B.P. It could be a contaminant introduced during excavation or collection of the sample, although the charring makes this less likely.

ROOTS

Charred starchy root material is fairly common in the assemblage and was found at all sites except 45-OK-287/288. Root tissue identified as Lomatium (biscuit root, white "camass") was found at 45-OK-11, 45-OK-18, 45-OK-250 and 45-OK-258. The oldest reliably dated lomatium tissue is from the Upper Housepit 1 floor at 45-OK-11, approximately 4700 years old. The largest pieces of root were taken from a radiocarbon sample from a zone 3800 years old at 45-OK-11. Lomatium tissue was also found in occupation debris and features in housepits from 45-OK-250 and 45-OK-258 dated 3000 years B.P. Edible root fragments were found in flotation samples also containing "black" camas (true camas, Camassia sp. probably quamash), tissue from fleshy fruits, goosefoot seeds, hawthorn seed fragments and starch (root) material pressed into cakes.

Probable lomatium tissue was found in a pit feature from 45-OK-2A, and in housepit debris from 45-OK-2, 45-OK-11 and 45-OK-258. Two samples from the last site contained probable lomatium tissue with pine seed fragments. The oldest of these samples is 4700 years old, and the most recent approximately 1200-1100 years old.

Although species identifications cannot be made for our small fragments of root tissue, these specimens probably belong to plants with large storage roots such as _Lomatium canbyi_ (white "camas", chukaloosa), _L. farinosum_ or _L. macrocarpum_ (biscuit root, brother-to-the-chukaloosa). The first species is available from mid-March through April in lithosols above 500 m in Douglas County. The last two are available at low and high elevations on both sides of the river. We have harvested biscuit root as late as the last week in July in Coyote Canyon and at 45-DO-326. By then however, the roots can only be located by using the dried and friable leaves and stalks as signposts. According to Turner (et al. 1980:64-65,68-69), camas was sometimes eaten fresh; while other times it was boiled and dried, or pit cooked with lily bulbs and bitteroot (_Lewisii redivivia_). At least one kind was made into cakes and dried for winter. Apparently, white camas is about only lomatium species still gathered by tribal members today (Fredin 1983). The closest source of desirable black camas insofar as we have been able to determine is Creston, Washington 45 km (28 miles) southeast of Grand Coulee Dam. Both kinds of roots are best dug with a curved digging stick traditionally made from hardwoods. Today these implements are fabricated from iron, and at least one local blacksmith does a good business providing them for the spring harvest.

We have harvested both _Lomatium canbyi_ and _L. macrocarpum_ in timed experiments. Figure 13-9 shows the growth habit of _L. macrocarpum_ among basalt rocks in June. Edible plants in association include bitter-root, Indian celery (_L. ambiguum_) whose seeds are good flavoring, and wild onion. Rocks and basalt spalls made digging most difficult, but we were able to extract six roots with a fresh peeled weight of 51 grams in less than 30 minutes. The largest specimen weighed 28 grams. In a second experiment we were able to collect 13 roots weighing 95 grams in the same length of time. The roots were exceptionally easy to clean by simply rubbing the skin with the fingers.

We found that the best way of gathering the roots was by making a hole by prying out the rocks and removing roots as the hole was continually enlarged. At the first site, we finished leaving an oval hole some 10-15 cm deep and 65 cm across. After the rocks had been replaced and the scars of the excavation had been smoothed over, it was noted that there were other similarly filled depressions at the site. Harvesting must have taken place some time ago as the rocks were lichen-coated and some soil had drifted among the replaced rocks. We may have discovered an archeological signature for root extraction in rocky soil.

About 1% of the flotation samples sometimes contain material which appears to be the charred outer covering of fleshy fruits. All of the specimens were so small that further identification was not attempted.

OTHER TISSUE

The last major category in the botanical assemblage consists of items such as nonedible seeds, leaf tissue, fiber and bits of non-woody tissue which cannot be identified futher.

NONEDIBLE SEEDS

The largest subcategory consists of charred seeds from bitterbrush (Figure 13-10). Seeds are found singly at all sites from the earliest layers to the most recent, and in large concentrations which range in age from 2800 to 600 B.P. The largest concentration, 1445 seeds, is from a flotation sample at 45-OK-250. Others containing from 500 to 570 seeds were identified from 45-OK-288, 45-DO-204 and 45-DO-214. The smallest concentration, 34 seeds, is also from 45-DO-204. Contemporary rodents do collect the seeds, and we have found seeds in burrows. We have found other concentrations with animal remains such as fecal pellets, hair or chewed seeds over one meter below present ground surface in archeological sites. These have been rejected from our inventory. The concentrations described above were carefully examined for rodent remains. All the seeds were charred. None showed signs of gnawing by rodents, and a surprising number of the seeds have tiny bulges or explosive craters on their surfaces (Figure 13-11), which indicate that the seeds were fresh or wet when burned.

Bitterbrush seeds are good seasonal markers. They are known for fast dispersal once ripe. They can be gathered during the latter part of June, and branches tend to be bare by the first part of July. Two uses mentioned in the literature include using an infusion for the treatment of constipation and hemorrhage (Ray 1932:217), and as a red dye plant (Chamberlain 1892). Since the seeds are quite large (about 6.0 mm long) and easy to spot, it is not surprising that they are one of the most common seeds in the assemblage.

Other nonedible seeds from the assemblage include three tule or bulrush seeds from a hearth at 45-OK-288; a sagebrush plantain (_Plantago patagonica_) seed from 45-DO-204, and six native wildflower nutlets (_Phacelia linearis_) in two flotation samples from 45-OK-2 and 45-DO-204. None are older than about 750 years B.P. and all are found locally today.

FIBERS

No bulrush fragments were identified in our flotation samples or carbon samples, but portions of an uncarbonized tule mat were found in a burial dated around 500 years B.P. at 45-DO-244.

Other kinds of fibrous material include Indian hemp (_Apocynum_ sp.) from 45-DO-204 with a date of 1100 B.P. and hemp cordage from the tule mat at 45-DO-244. The hemp from 45-DO-244 is unspun fibers stuck to melted resin or pitch on ryegrass stems. Bow strings, netting and matting of Indian hemp cord were found at the Upper Coulee rockshelter by Mills and Osborne (1952:354-

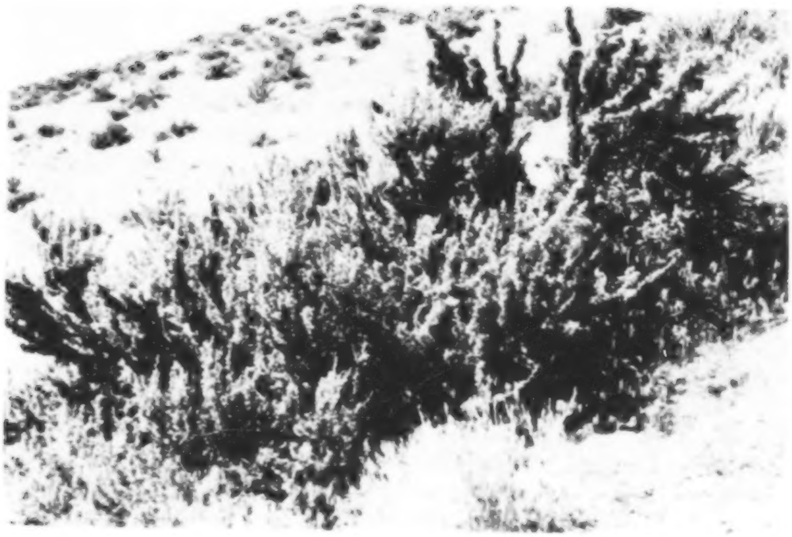

Figure 13-10. Bitterbrush (Purshia tridentata), fruiting stage.

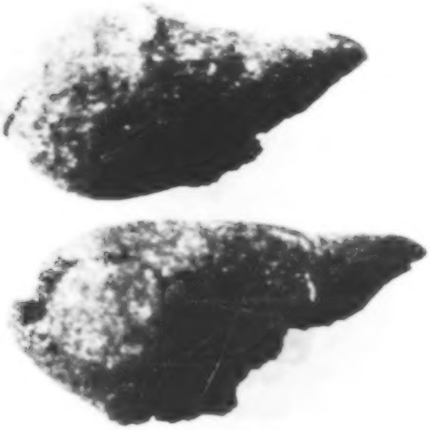

Figure 13-11. Archaeological bitterbrush seeds from a concentration, 45-DO-204. Seeds are 5.8 and 6.0 mm long.

355,357). Ethnographic uses for the fiber are too numerous to detail. In general, hemp was used when fine cordage of great strength and durability was needed: for deer and fish netting, bowstrings, weft elements for mats and grass, clothing, flexible storage containers, tumplines, slings, noose material, and for attaching haft elements (often pitch coated), and in constructing composite harpoons (Post and Commons 1938:57,60,63-64; Ray 1932:36,38,69,89). Ray also reports that hanks of the material were included in sewing kits complete with bone needles and other objects (Ray 1932).

The harvesting of hemp and bulrush are fall activities. The largest local aboriginal hemp stands are said to have been located at the southern end of Omak Lake (Post and Commons 1938:36), where the plants apparently were numerous enough to draw families for a two week harvest (Ray 1932:36). Plants were cut, soaked to loosen the fibers from the stem, scraped with a sharp flint, and rubbed by hand into bundles or into cordage of various thicknesses. Bulrushes could be gathered from nearby Goose Lake at the same time.

Several small bits of fibrous material were found which appear to have been modified and split from inner layers of hardwood bark. Two samples from 45-OK-258 made from willow or poplar bank date between 2700 and 500 years old. An 1100 year old feature at 45-DO-214 yielded a very finely wrapped haft made of bark fibers glued with pitch and colored with red pigment; the bark used was either birch or alder.

GRASS STEM

Grass stems without fruiting material are often difficult to identify. We have found dropseed (Sporobolus cryptandrus) and giant ryegrass (Elymus cinereus) from about 1200 years ago. In general, almost any feature may have traces of grass stems, but they are most common in protected parts of housepits and pit features.

LEAF

Herbaceous leaf material is fairly rare and usually cannot be identified. We could identify some leaf material with distinctive characteristics, e.g. the cross section of conifer needles or the small, leathery leaves of sage. Flotation samples have yielded traces of hackberry (45-OK-2), sage (45-OK-18), oceanspray (45-DO-214), and bitterbrush (45-DO-214) leaf material. The oldest is oceanspray, associated with a feature date of 1151±168 B.P. The oldest conifer needle is about 3200 years old (see section under conifer woods).

OTHER

Other delicate material from the assemblage include two examples of lichen from 45-OK-287 and 45-DO-214 about 1200 years old. The material is probably wolf "moss" (Letherla sp.). The lichen from 45-OK-287 was not found in a feature, and its inclusion may be natural. A very small amount was found in a feature at 45-DO-214. It may have been carried in on the bark of the wood in the feature. At low terraces near the river, wolf lichen grows on sage and bitterbrush stems. It was used as a yellow dye by Okanogan-Coville peoples (Turner et al. 1980:15).

Figure 13-12 is an example of finely twisted material which may not be floral in origin. Three fragments of this "cordage" have been found in occupation debris from 1100 and 3000 years old. None exhibits the cellular structure familiar from regional cordages such as Indian hemp, nettle, willow and other bark fibers. The twist is uniform and the width does not exceed 0.4 mm. It is possible that the material is animal sinew.

While remains of horsetail rush (Equisetum sp.) itself have not been found in our samples, striae on some bone and soft stone objects apparently were caused by abrading with horsetail. Such abrasion marks were found on a steatite pendant (Figure 13-13) and another formed steatite object from House 6 at 45-OK-2, dated between 1800 and 1830 A.D. A bone awl bearing similar abrasion marks was found in Feature 31 at 45-OK-250, associated with the floor of Housepit 2, which predates 2000 B.P. Horsetail was a useful smoothing material in the past (Post and Commons 1938:59). Abundant in thickets and under shade, it may be gathered at any time during the year.

COMMENTS ON PRESERVATION, RECOVERY, AND IDENTIFICATION

Besides listing types and quantities of plants in the assemblage, we can make several important observations about preservation. First, we found that even delicate tissues, such as stem and pith fragments, survived in the oldest samples, those from about 4,600 years ago. Second, we discovered that unburned plant cells can survive for as much as 3000 years under the preservation conditions obtaining at project sites. Partially carbonized lodgepole pine branch wood was found in pit Feature 96 at 45-OK-250, associated with a series of floors in Housepit 3 which date between 2324±125 and 2851±103. Partially carbonized larch and birch wood were recovered from Feature A at 45-OK-11, which is associated with a date of 3557±523. Incompletely carbonized wood is more common, however, after 1500 B.P. Therefore wood need not appear totally black to be considered archaeological, particularly in deposits less than 1500 years old. Happily, this means that carbon samples that might have been dismissed as intrusive and unworthy candidates for dating may now be considered. Unhappily, this makes it more difficult to recognize contaminated samples. Finally, we found that the amount of soil collected for botanical samples should be increased with excavation depth. While a 100 g soil sample was adequate for obtaining a 0.10 g subsample of carbon from most upper sediments, at depths close to 2 m a 1,000 g sample might yield only 0.02 g of carbon. The decrease in carbon density with depth is not due to preservation factors alone, rather it is a function of lower densities of cultural materials and more rapid depositional rates at the base of many of our riverine sites. To insure 0.10 g subsamples under these conditions, it is advisable to collect 5 to 10 kg of soil below 2 m (or in sediments older than 2,000 years).

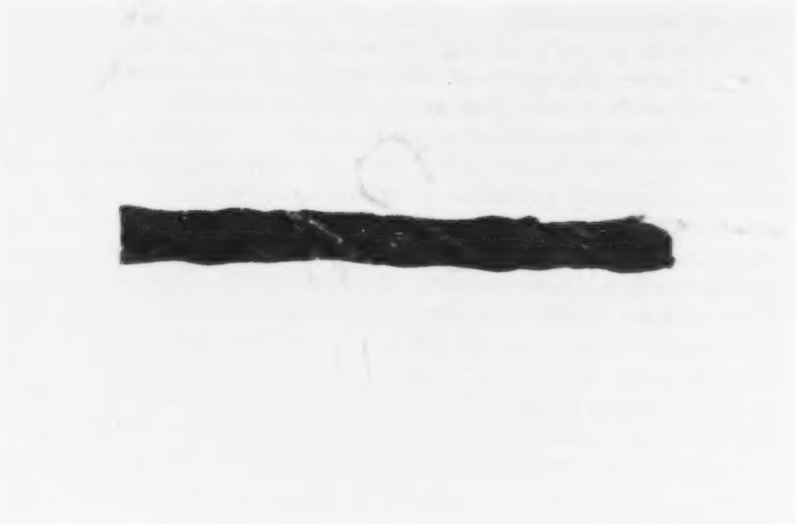

Figure 13-12. Sinew or fiber cordage from 45-OK-2. Specimen is 0.3 mm wide.

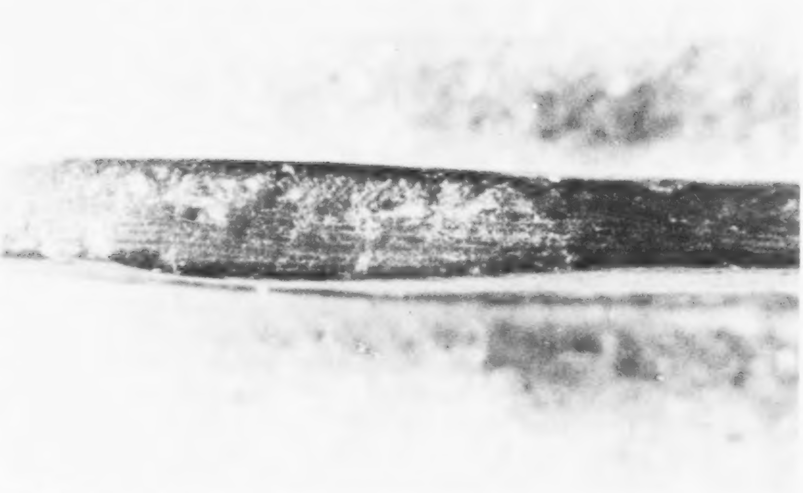

Figure 13-13. Horsetail (Equisetum) abrasions on edge of steatite pendant, 45-OK-2. Magnification: 10X.

The assemblage described above was derived from radiocarbon samples as well as flotation samples. We had not originally planned to include bulk carbon samples because of the obvious difficulty of comparing these different types of samples. However, including the radiocarbon samples turned out to be very helpful. It contributed to our ability to identify woods and increased the number of identified taxa beyond that found in the flotation samples. Radiocarbon samples sometimes contained manufactured items like boards and planks which showed evidence of technical processes. Finally, familiarity of working with radiocarbon samples along with flotation samples, allowed us to coin our first rule of thumb for botanical analysis--sites with enough carbon for radiocarbon dating have enough carbon for archeobotanical analysis.

Forty-two or 75% of the taxa were identified from 220 flotation samples analyzed in the first 10 months of the analyses (Figure 13-14). Fully 95% of the taxa were identified in 355 samples. Thereafter, new identifications slowed as redundancy became common, and only three new species were added in the remaining 104 flotation samples.

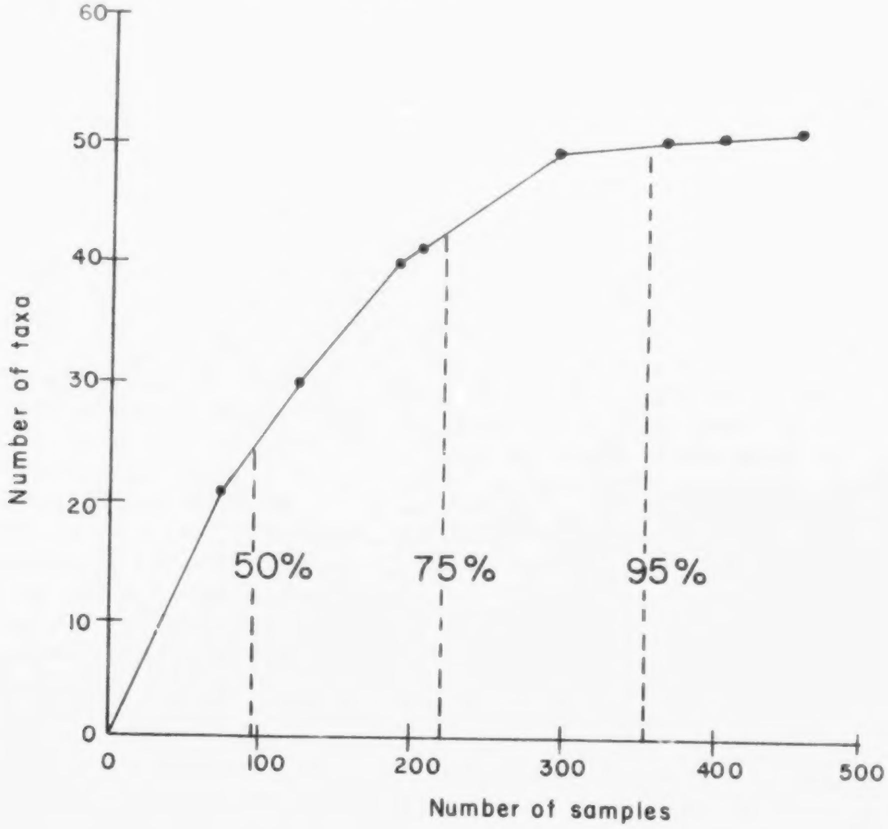

Figure 13-14. Cumulative frequency of taxa by number of samples (samples from eight sites).

Given the above results, it is probable that judicious selection of sites for future flotation samples would result in more taxa recovered from fewer samples analyzed. The ratio of carbon to soil, which we calculated for all flotation samples, is helpful in indicating the richness of samples. This ratio was calculated as a means of measuring comparability between flotation samples collected before 1980 which had been screened, and later samples which had not. A rich sample contains 1% or more carbon by weight and a poor one has less than 0.1% archeobotanical material by weight. This in turn, has given insight into which features provide the best samples. Firepits and hearths are, not unexpectedly, consistent floral producers; however, there are other types of features which produce as much floral material as these. Good yields have come from samples taken from small pits under 50 cm in diameter such as post molds and other small deep depressions where material cannot be easily trampled. Samples extracted from along structure walls, in corners, and in dumps near doorways have provided the best botanical arrays. Deposits exhibiting little crushing or mashing such as rock piles, or shell and bone concentrations have yielded good results. Thus our second rule of thumb is that areas protected from human trampling provide the best botanical samples.

THE SEASONAL ROUND OF PLANT HARVESTING

The seasonal round described in the literature and our own investigations concerning harvest times and abundance, indicate that wild stocks were abundant and considerable freedom could be exercised with respect to food preferences. The times of the biggest harvests--roots in spring, serviceberries in mid-summer, and cherries in late summer--are sufficiently separated in time to allow ample collection and processing.

Even with relatively long travel times to choice lomatium grounds in the spring, the season is long enough for quantities of L. canbyi (the current first choice among lomatiums) to be accumulated. Or, if that harvest is missed, there are other roots which can be gathered later in the root season, such as L. farinosum and L. macrocarpum, closer to the river. If we as inexperienced root gatherers can accumulate 1000 gm of cleaned root material from a square meter of land in 30 minutes, surely experienced gatherers can collect several times that amount in known territory.

An experienced cook may moniter the local vegetation closely in order to gather the prime or "best" varieties of serviceberries at the beginning of the season in June. Other gatherers could still collect sufficient quantities by taking other varieties or traveling to higher elevations later in the season. The same may be said for chokecherries in August, or hawthorns in September. Important cordage and matting material stands may be visited anytime after that in draws or by the lakeside without conflicting with other harvests.

In short, there are very few scheduling conflicts that we can envision with respect to floral products. Times between the major harvests of roots, serviceberries, and chokecherries allow time to gather other foods such as wild currents, oregon grapes, sunflowers seeds, chenopod seeds and leaves and other items.

COMPARISON BETWEEN PHASE ASSEMBLAGES

One of the most intriguing discoveries in the analysis of the Rufus Woods botanical assemblage is the change in the relative abundance of some taxa over the last 5000 years and relative constancy of others. Comments were made above about the occurrence of particular taxa in time; here we focus on changes in proportional representation of taxa, as shown in the flotation assemblage grouped by phase (Table 13-2). By studying the groups of taxa which behave in a similar manner we can suggest whether the causes of change are local or regional environmental change or changes in human behavior.

Considering first the largest groupings (Figure 13-17), we note that the relative abundance of conifers has decreased through time, while the abundance of hardwoods and the Other category have both increased. The proportion of edibles has remained roughly constant. To interpret the significance of these changes, we must look at the constituent taxa which determine these trends.

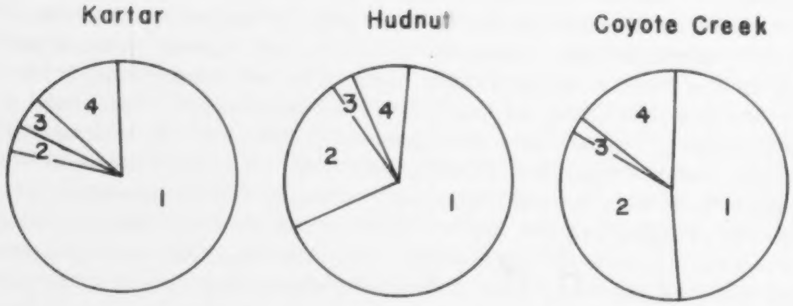

Figure 13-15. The botanical assemblage by phase. 1=Conifer, 2=Hardwood, 3=Edible material, 4=Other.

While the relative proportion of conifers as a whole decreases over time, the number of conifer taxa increases. Certain taxa (ponderosa pine, larch) became relatively less frequent through time, while the relative frequency of other conifers (red cedar, yellow cedar, white pine, Douglas fir, yew) increased over the same span in time. Spruce, hemlock, juniper, and lodgepole pine all have their greatest frequency in the Hudnut Phase. The grouped categories reflect these trends. We believe that the decrease of nonwoody conifer materials such as bark and cone fragments simply reflects the general decrease in pine family members, since most of items in these categories are pine. Although Cupressaceae includes juniper, which occurs in greatest abundance in the Hudnut Phase, the category is dominated by red cedar and yellow cedar, and it follows the same trend of increasing through time. Undifferentiated yellow pine includes both lodgepole and ponderosa pine, which do not show the same relative frequency trends. As ponderosa pine is far more abundant than lodgepole in the samples, it is not surprising that the undifferentiated category mirrors the ponderosa trend, decreasing through time. While Pinus contorta can be distinguished from P. ponderosa in bole wood, the two are difficult to distinguish in samples which contain mixed branch and trunk material. If there was any uncertainty about the composition, a mixed sample was designated as yellow pine to include both woods. The Pinaceae category as a whole, probably dominated by ponderosa pine, also reflects this trend.

In order to interpret changing proportions of taxa, we need to characterize each taxon on three different dimensions. First, we need to recognize whether a particular type of wood was used primarily for fuel or reserved for construction and artifact manufacture. Assuming that fuel gathering is extremely opportunistic, minimizing time and effort, fuel woods probably reflect the abundance of woods in the immediate local environment. On the other hand, we have evidence that certain woods were strongly preferred for construction and artifact manufacture and were not used as fuels. The occurrence of these rare woods does not necessarily reflect their occurrence in the environment. The variations in the frequency of these woods may indicate more about settlement patterns than about changes in wood abundance. Secondly, we must consider the source of a particular taxon. Some species do not occur now in the region and probably were obtained from river drift. Of the species which are now known on the Colville Reservation, there are a number of species which occur only at higher elevations today whereas others are available at lower elevations in the reservoir. The abundance of particular exotic tree species in the river drift is not independent of regional climatic change, but may be independent of local climatic change. Finally, if we wish to look at changes in local and regional environment, we need to assess whether a given taxon prefers relatively more xeric or mesic environments.

We argued above that ponderosa pine, larch, Douglas fir, bitterbrush, sage, and possibly mock orange were used primarily for fuel. Table 13-2 shows a gradual decrease in Ponderosa pine and larch, and an increase in the two hardwood species. The proportion of Douglas fir increases slightly through time while the proportion of juniper remains approximately the same. The proportional changes in these taxa suggest a greater initial reliance on locally available conifers for fuel and an increasing substitution of hardwoods through time. The change from conifer hearth fuel to shrubby hardwood was a gradual, quantitative change, not a qualitative change. During the Coyote Creek Phase, ponderosa and lodgepole pine branches are still found in hearths with other conifer species, but the predominance by weight has shifted in favor of more xeric steppe shrubs (sage, bitterbrush and mock orange).

Several exotic conifers (red cedar, yellow cedar, white pine, yew) and two conifer species currently available in the local area above 900 m (hemlock and spruce) were used primarily for construction and artifact manufacture. The condition of these woods and the contexts in which they are found indicate that they were not used for fuel, but were reserved for construction or artifact manufacture. In contrast to yellow pine, larch, and Douglas fir, the specimens of red cedar, yellow cedar, and yew, are mature bole wood. Almost no branch material suitable for firewood is present, and a high percentage of samples contain partially charred wood. Very little bark, and no needles or cone material from these exotic conifers are present. It appears, therefore, that whatever adjustments in fuel use occured over time, the best wood-working materials were saved for construction and tool-making purposes. The splitting of trunk material from such species requires a few, simple, but indispensable tools such as wedges and a hammer or maul to rive them uniformly along the grain. Such techniques are clearly demonstrated from Structure N, a Coyote Creek Phase structure at 45-OK-2. Every wood which can be efficiently split in this manner is present.

Of the woods reserved for construction and not burned for fuel, all of the exotic species are found in greatest abundance in the Coyote Creek phase assemblage. We cannot argue from this that these woods were more frequent in the driftwood at this time, or that this reflects a change in human selection. The sample is possibly biased because of the unusually large sample of woods from Structure N at 45-OK-2. It is likely that the human inhabitants selected precisely the same woods from the river drift throughout the span of occupation and our sample does not include equal representation of house timbers for all phases. The other two construction species, spruce and hemlock, have their highest proportions in the Hudnut phase assemblage. Because these do occur in the immediate area, although at higher elevations, it is possible that their occurrence reflects a changing local distribution or abundance. These species are more mesic and found at higher elevations than the other local conifer species; possibly they would be found at lower elevations during cooler and moister conditions.

One cannot help wondering whether river drift today would be sufficient for domestic purposes under pre-white (pre-dam) conditions, or whether adjustments in fuel-gathering techniques or village placement might become necessary under today's denuded conditions. We doubt that conditions anytime in the past 5000 years would mirror today's open, fairly dry environment. If anything conditions might have been more mesic.

In contrast to the shifts in wood, the food array represented by roots (Lomatium spp.), and fruits (serviceberry, cherry) remain remarkably constant over time. As sampling strategies are developed for floral food recovery, we expect that information concerning other edibles such as goosefoot, sunflower, strawberry, haws and black camas will expand. It is of note that none of the floral foods often mentioned as famine fare (cactus, black "moss" or lichen, rosehips) were identified in quantity. It would appear that stocks of vegetable materials were sufficient.

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14. FEATURES

by Dorothy Sammons-Lohse

The purpose of this chapter is to summarize information on features recovered by the project. The first section is a descriptive summary of feature classes, emphasizing contrasts between phases. The implications of changes in feature representation, form, and content for change and stability in the prehistoric communities in the project area are considered in the final two sections.

The analysis and classification of features is discussed in the project's research design (Campbell 1984b). The functional typology devised for the project considered six basic types of features--housepits, firepits, pits, occupation surfaces, debris scatters, and stains--and an "Other" category (Table 14-1). Firepits and pits are divided further into interior (inside

Table 14-1. Feature types recorded at Rufus Woods Lake.

Feature Type
1. Housepits
A. Floors
B. Walls/Rim
C. Fill
2. Firepits
A. Interior Firepits
B. Exterior Firepits
3. Pits
A. Interior Pits
B. Exterior Pits
C. Postholes
4. Exterior Occupation Surfaces
5. Debris Scatters/Concentrations
A. Bone Concentrations
B. Fire-modified Rock Concentrations
C. Shell Concentrations
D. Mixed Debris Concentrations
6. Stains
7. Other
A. Cultural Strata
B. Artifact Clusters

houses) and exterior (outside houses) examples. Pits include postholes and other pits. Debris scatters are divided into rock, bone, shell or general debris scatters. The type "cultural stratum" was used at some sites but, because cultural strata were not featured consistently at all sites, it was dropped into the catch-all "Other" category. We had also formulated a "walls/rim" category, but housepit walls were recorded separately only at 45-OK-11 (and one at 45-OK-2), so this category will not be discussed at length here. While finer groupings would be more useful for some purposes, these inclusive categories have the advantage of larger sample sizes and minimizing biases due to inconsistencies in excavation or recording.

HOUSEPITS AND INTERIOR FEATURES

Eight of 18 sites excavated contained structures. One site, 45-OK-11, yielded remains of at least 11 housepits dating to the Kartar Phase (6000-4000 B.P.), the earliest of three cultural phases defined for Rufus Woods Lake. The housepits are among the earliest recorded on the Columbia Plateau or, indeed, in the Intermontane West. Five housepit sites date to the Hudnut Phase (4000-2000 B.P.), roughly contemporaneous with the Frenchman's Spring Phase (Nelson 1969) of the middle Columbia, and three sites with housepits were dated to the Coyote Creek Phase (2000-50 B.P.).

KARTAR PHASE HOUSES

Eleven probable pit houses dating to the Kartar Phase were found at 45-OK-11 (Table 14-2); three were extensively excavated. The oldest, dated to 5100 B.P., is among the earliest examples of housepits on the Columbia Plateau, predating similar examples at Hatwai (Ames et al. 1981) and Alpowai (Brauner 1976) by nearly eight hundred years. In addition, a shallow excavation from which cobbles had been cleared, at 45-OK-2, may also represent a Kartar Phase structure; it dates to 4590 B.P. (Campbell 1984a).

Only three housepits at 45-OK-11 were sufficiently exposed to determine size and shape; dimensions for others are more tenuously offered (Table 14-2). At least two of the housepits at 45-OK-11 are curvilinear; that is, they have rounded corners and at least two straight sides. In this, they are similar to House 1 at Hatwai, dated to 4340±90 B.P., which is "subrectangular"; there, however, all similarity stops. House 1 at Hatwai contained a wide bench, central pit, and ramp. No such features occur in any of the Kartar Phase houses at 45-OK-11, where possible side entryways, small firepits, and small interior pits mark the floors.

Wall treatment at 45-OK-11 varies considerably from housepit to housepit. Shallower pits (30-40 cm) tended to have moderately sloping walls (less than 50 degrees), while the deeper structures (60-80 cm), in general, had steep, nearly vertical walls. Even within a single structure, however, (e.g. Upper Housepit 1), both vertical and sloping walls might be found. In housepits with sloping walls, floor area might be severely constricted relative to the rim dimensions (see Table 14-2).

Table 14-2. Kartar Phase housepits.

Site	Structure	Radiocarbon Date	Size	Depth	Shape	Walls	Floors	Firepits	Pits	Postholes
45-OK-11	Lower HP1	5047±249	10 x 10 m rim 10 x 8 m floor	Unknown	Curvilinear	Vertical sloping	1-2	2	7	2?
	Upper HP1	4719±156	12 x 12 m rim 7 x 7.5 m floor	30 cm	Curvilinear	Sloping	1	2	-	-
	Housepit 2	4872±142	Unknown	40 cm	Unknown	Steep	1	-	-	-
	Housepit 3	5109±154	Unknown	40 cm?	Unknown	Sloping?	1	-	-	-
	Housepit 4	4200±180 4564±150	9 m diameter	80 cm	Curvilinear	Steep	1-2	1?	-	-
	Housepit 5	4757±157	Unknown	50 cm?	Unknown	Unknown	1?	-	-	-
	Housepit 6	-	>6 m	65-85 cm	Unknown	Steep	2	-	-	-
	Housepit 7	-	Unknown	40 cm	Unknown	Steep	1	-	-	-
	Housepit 9	-	Unknown	40 cm	Unknown	Steep	1	-	-	-
	Housepit 11	4434±117	10 m?	40 cm	Curvilinear	Sloping	1	1	-	-
	Housepit 12	-	>6 m	80 cm	Circular	Steep	1	-	-	-
	Housepit 13	5171±151	>8 m	60 cm	Unknown	Sloping	1	-	-	-

In some cases, sloping walls seemed deliberately lined with shell; note, in Table 14-3, the extremely high density of shell in the walls/rim category for the Kartar Phase. Either the shell was deliberately placed in an attempt to stabilize an existing wall, or the occupants merely used a convenient resource (in this case, an adjacent shell midden) to modify or cover a wall. The latter seems more likely. Indeed, in Upper and Lower Housepits 1, the shell walls cover earlier sloping walls in which possible side entryways had been recorded. These earlier walls showed no sign of slumping and no evident need of stabilization.

Interior Features

Within the Kartar Phase housepits, there was also a great deal of variation in the configuration of floor features. No firepits or other pits occur in the floor of Housepit 4 at 45-OK-11; there was one unstructured feature, a moderately dense cluster of shell and fire-modified rock (FMR). By contrast, Upper and Lower Housepits 1 contained several interior pits and prepared firepits. Two firepits and several piles of fire-modified rock occurred in Lower Housepit 1; two larger, partially eroded firepits were in Upper Housepit 1. Interior firepits also were recorded in Housepits 9 and 11. These Kartar Phase firepits are shallow, but were either more carefully constructed or better preserved than examples from the Hudnut Phase which seem to have been built on the housepit floor rather than excavated into it.

Although some of the interior pits were recorded to be as much as one meter in diameter, most are around 50 cm across and 20 cm deep. Except for one example which appeared to be lined with shell, the interior pits are conspicuously lacking in material. Kartar Phase pits may have been used for storage rather than disposal. The floor area around them contained less material than other parts of the floor and we have conjectured that this section of the housepit was used for sleeping and storage. The extremely large average size of bone pieces (inferred from mean bone weight, Table 14-3) in these interior pits may indicate the presence of large pieces of meat (stored?); interior pits in the Hudnut Phase, which we have taken to be trash pits, have a much smaller mean bone weight.

Postholes are notable for their absence in the Kartar Phase. Although two possible postmolds were noted in Lower Housepit 1 at 45-OK-11, along the north and south walls respectively, we have no evidence as to the superstructure above the pit. It may be that the footings of posts were on the rim outside the housepit.

Organization of Activities

Daily activities within the housepits were not confined to specific areas of the structure, judging from the three nearly complete floors recorded at 45-OK-11. Housepit 4, with its clean floor and lack of interior features, gives very little evidence of where activities took place within that structure. In Lower Housepit 1, however, the several interior firepits were apparently the focus of stone tool manufacturing and some food processing,

Table 14-3. Density of material from housepit floors and interior features by phase.

Feature Type	Phase	N	Vol m^3	Bone			Shell		FMR		Tools	Debitage	Deer/deer-sized Bone	Salmonid Bone
				N/m^3	gm/m^3	N/gm	Hinges/m^3	Total gm/m^3	N/m3	gm/m^3	N/m^3	N/m^3	NISP/m^3	NISP/m^3
Housepit Floors	Karter	11	26.27	607	272	0.44	474	2131	40	7757	7.3	69	10.0	0.4
	Hudnut	18	53.06	4153	1190	.28	362	1187	72	10766	14.0	216	66.0	9.0
	Coyote Creek	16	29.88	2193	758	0.34	70	?	131	28925	18.0	224	74.0	5.0
Housepit Walls/Rim	Karter	2	26.89	590	240	0.40	2635	12201	40	5820	9.8	78	9.0	1.3
Interior Firepits	Karter	5	0.56	507	191	0.36	223	1550	185	32520	14.0	20	9.0	0.0
	Hudnut	7	0.84	4746	1087	0.23	745	1680	205	686618	14.0	171	79.0	0.0
	Coyote Creek	12	1.40	2261	542	0.24	8	4	216	64700	19.0	429	23.0	0.7
Interior Pits	Karter	9	1.20	219	157	0.71	502	4067	12	4665	2.5	20	9.0	0.0
	Hudnut	23	3.06	1943	811	0.47	128	311	38	8520	21.0	256	57.0	2.3
	Coyote Creek	5	1.36	644	57	0.03	17	18	12	1132	3.0	21	1.4	3.7
Postholes	Hudnut	50	2.30	556	148	0.26	33	71	18	10400	0.4	10	9.4	0.4
	Coyote Creek	8	0.95	230	36	0.15	4	4	4	484	3.0	1	0.0	0.0

while the interior pits and floor space around them were relatively sparse in material and may have been used for sleeping and storage. Upper Housepit 1 showed yet another pattern of use: In Upper Housepit 1, we identified a possible plant processing area as well as meat processing, tool manufacture and disposal areas, and two firepit-and-milling stone pairs. Following Brauner (1976), we have speculated that these two clusters of artifacts may indicate the presence of at least two families or an extended family in the dwelling.

Summary

In sum and based on our limited sample, we find that the Kartar Phase housepits vary in construction details, but are curvilinear in shape, occasionally have shell-lined walls, contain small excavated firepits and small interior pits sometimes lined with shell, lack postholes, and housed several domestic activities, some of which focused on the several firepits with special areas set aside for sleeping and storage.

HUDNUT PHASE HOUSES

Nineteen housepits at five sites date to the Hudnut Phase (4000-2000 B.P.). Table 14-4 summarizes the salient characteristics of these housepits.

Again there is a great deal of variation among these structures from site to site and within sites. Shape is consistently circular to oval, with none of the straight-sided structures seen at 45-OK-11, but size ranges from five to 11 meters across, and 20 to 160 cm in depth. Unlike the tenuous correlation noted for Kartar housepits, there is no association in the Hudnut structures between depth and wall construction: steep-walled housepits may be either very deep (e.g., Housepit 1 at 45-DO-242) or shallow (Housepit 3 at 45-DO-211), and deep housepits may be steep-walled or basin-shaped (Housepit 3 at 45-DO-242).

Interior Features

Seven interior firepits are recorded in Hudnut Phase housepits; others may have been present but recorded as part of the floor by excavators. Unlike their counterparts in the Kartar Phase, Hudnut Phase interior firepits were not prepared; they were not excavated into the floor or lined. Apparently, the Hudnut Phase central "hearths" were simply burning areas, outlined by large rocks (note the extremely high density of FMR by weight in Hudnut Phase interior firepits, Table 14-3). What remains of the hearths archaeologically is a blur of fire-modified rock, charcoal stain, and reddened earth across the center of the structure. The central location of firepits is distinctive of the Hudnut Phase; while Kartar Phase housepits contained two firepits located toward the walls, the hearth area in the Hudnut Phase always is in the center of the structure. Whether this shift reflects a change in the size of organization of the family unit occupying the structure or in the position of the entryway or construction of the superstructure is open to conjecture.

Table 14-4. Hudnut Phase housepits.

Site	Structure	Radiocarbon Date	Size	Depth	Shape	Walls	Floors	Firepits	Pits	Postholes
45-DO-211	Housepit 1	3636±100	6 m diameter?	70 cm	Oval	Steep	1	–	3	–
	Housepit 2	2712±86	6 x 5 m	80 cm	Oval	Steep	1?	1	2	?[1]
	Housepit 3	–	Unknown	50 cm	Unknown	Steep	1?	–	–	–
	Housepit 4	–	Unknown	40 cm	Unknown	Sloping	2	1	–	–
45-DO-242	Housepit 1	–	5 m diameter	160 cm	Circular	Steep	1?	–	–	–
	Housepit 2	3066±232 3912±459	8 m diameter	100 cm	Oval	Sloping	2+	1	1	?[1]
	Housepit 3	–	5 m diameter	70 cm	Unknown	Steep	1	–	–	–
45-OK-2	Housepit 1	–	Unknown	Unknown	Unknown	Unknown	1	–	–	2
	Housepit D	–	Unknown	20 cm	Unknown	Sloping	1	1	–	–
45-OK-4	Housepit 2	2097±132 (upper floor)	10m+ diameter	<80 cm	Circular	Vertical, Sloping	2	?[2]	2	1
	Housepit 5	3085±114 (lower floor)	7 m diameter	80 cm	Circular	Vertical, Sloping	2+	?[2]	5	?[1]
	Housepit 6	2438±145	Unknown	80 cm	Unknown	Vertical	1	–	–	–
	Housepit 7	–	Unknown	Unknown	Unknown	Vertical, Stepped	1	–	–	–
	Structure A	2360±134	4 m diameter	30 cm	Unknown	Sloping	1	?[2]	–	–
45-OK-250	Housepit 1	2989±76 3219±85 3453±97	11 x 9 m	50 cm	Oval	Sloping	1?	?[2]	2	15
	Housepit 2	–	Unknown	40 cm	Unknown	Sloping	1	–	–	–
45-OK-258	Housepit 3	–	7.5 x 9.5 m	130 cm	Oval	Sloping	2+	1	8	9
	Housepit 4	–	Unknown	60 cm	Unknown	Steep	2+	1	3	–
	Housepit 5	2787±103 2876±216 2951±107	9 m diameter	80 cm	Circular	Vertical	3+	2	4	10

[1] Indicates possible postholes not recorded seperately by excavators, or that some of the "interior pits" might have been postholes.

[2] Indicates presence of a central fire hearth which was not recorded seperately by excavators.

While we believe (and will argue at greater length below) that there are social changes from the Kartar to Hudnut Phase, the relocation of the fire in the dwelling may merely reflect physical differences in the structure itself.

Pits found in Hudnut Phase housepits also contrast with those from the Kartar Phase. In at least two of the Kartar housepits at 45-OK-11, interior pits were several, small, and generally empty (except for a possible shell lining). By contrast, during the Hudnut Phase, interior pits occur less often but usually are larger and replete with debris. From the high densities of bone, rock, debitage, and even stone tools, but not shell (Table 14-3) we infer that most of them are trash pits. We must be cautious in inferring function as the pits could be abandoned storage pits later filled with trash. Some did apparently serve special functions, such as the pits in Housepit 3 at 45-OK-258, which contained anvil or grinding stones and large quantities of crushed bone; or, in the same structure, pits which may have footed large support posts. While 30 interior pits were recorded within Hudnut structures, few floors contained more than two (Housepit 3, 45-OK-258, being a notable exception with eight). The dissimilarities between interior pits of the Kartar and Hudnut Phases suggests, again, that the role these features played in day-to-day activities may have shifted.

The 37 postmolds recorded separately in Hudnut structures, as well as possible postholes which were recorded as pits or depressions, provide the most striking contrast with Kartar structures where no postmolds were recorded. Unfortunately, these holes and remains of posts give us little indication of the dwellings' construction. At 45-OK-258, the alignment of postholes and larger pits in Housepit 3, thought to have held major beams, indicated a quadrilateral support system, while in Housepit 5, an arcing pattern of smaller beams was noted. The major problem in discerning patterns in the numerous postmolds is the presence of multiple floors, each floor containing only a few postholes which do not align with post positions in earlier or later floors. Postholes from the Hudnut Phase contain more trash than those in Coyote Creek Phase housepits (Table 14-3), perhaps because posts were removed when the house was abandoned and material from the next occupation sifted in. Especially striking however are the number and size of fire-modified rock in the Hudnut Phase postholes: using rocks to provide a stable footing for supports seems to be characteristic of this time period (note the high density of FMR by weight in the Hudnut Phase, Table 14-3).

Organization of Activities

Activity areas are more difficult to delineate in Hudnut than in Kartar Phase dwellings; the collapsing of many years of use into a single floor or several floors into a single feature number makes it impossible to tease out a short-term picture of activity. However, there is evidence of processing activities in the Hudnut dwellings which was not found in Kartar Phase houses. Whether these activities were not represented in our sample of Kartar Phase houses, were outdoor activities during that phase, or were first practiced in the Hudnut Phase, is uncertain. The evidence for new activities being practiced indoors is not overwhelming, but does suggest that real changes in daily organization were taking place. We have already mentioned changes in the locations and construction of firepits. A second line of evidence is the high density of material in the vicinity of the central firepit which indicates that it served as a focus of activity--all kinds of activity--which the Kartar examples did not exhibit. Of course, we also have noted the many floors and reoccupation of Hudnut Phase housepits, and the high density of material in Hudnut features may simply reflect this intensive, continuous use. Therefore, density measurements alone cannot bear the burden of proof. However, a third indicator of new and different activities taking place within Hudnut Phase housepits lies in the many pits and debris scatters which cover the floors. Unlike in the Kartar Phase, several very dense bone scatters occur on Hudnut Phase housepit floors, as do examples of lithic workshops (see Housepit 1 at 45-OK-250, for example) and concentrations of salmon bone (often as complete skeletons). Some pits reflect a specialized use, such as the pits filled with crushed bone at 45-OK-258, Housepit 3.

Another aspect of changing activities within Hudnut Phase housepits is indicated by the faunal and artifact assemblages within these housepits. We do not use these assemblages to pinpoint the location of specific activities within the houses themselves, but rather to look at the structure as a whole and so to examine the role of the dwelling within the site, and by extension, the site within the system. In our report on the excavation at 45-DO-211, we noted that, of the four housepits uncovered there, two held abundant salmon remains, while the other two contained much deer or deer-size bone. The latter two also yielded more projectile points from the floor, and we suggested (following Brauner 1976) that the projectiles were carried into the housepits with the meat and were removed during final processing. We also suggested that 45-DO-211 shows that the ethnographic pattern of winter dwellings and summer fishing camps, noted for the Nespelem and Sanpoil by Ray (1932), was in place as long as 3,000 years ago. The sequence of houses at 45-DO-211 show a shifting focus at the site--from hunting to fishing, back to hunting and then to fishing--and that the site served, in turn, as both a winter habitation and a summer/fall fishing camp. Later, we discerned a similar pattern among the pit dwellings at 45-OK-4, where several structures contained almost no fish bone while others seemed to contain little else. At Housepit 2, 45-OK-4, the earlier floor was littered with salmon remains while the second floor contained almost none. Therefore, we suggest that, not only were new activities being introduced into the dwelling at this time, but the dwellings themselves were evolving specialized functions within the yearly round. We have no evidence for this phenomenon in the earlier period.

SUMMARY

The Hudnut Phase housepit, then, is marked by its oval to circular shape, postholes, trash pits and special function pits, and a central hearth area around which activity of the day revolved. These housepits usually were occupied and re-occupied several times, often with extensive modifications to the original excavation, so that the archaeological record is, at its simplest, several sequential floors or, at its most complex, a series of overlapping pit structures of uncertain succession. Activity areas are similarly obscured by the complex stratigraphy, but it appears that the dwellings were being used for more numerous and and varied types of daily activities and were themselves evolving into season-specific structures.

COYOTE CREEK PHASE HOUSES

Structures dating to the Coyote Creek Phase were excavated at three sites (Table 14-5). Fifteen of the 17 structures were from adjoining sites 45-OK-2 and 45-OK-2A, which may have once been part of a continuous occupation area. The situation is similar to that for the Kartar Phase; the majority of the houses are from a single site and we do not know how representative that site is of all Coyote Creek villages or structures.

Houses at all three sites are generally circular pit dwellings, with diameters of less than 14 m (Table 14-5). Walls are either steep or gently sloping, sometimes both in the same structure. Some of the houses are very shallow, and may be considered surface structures, while others are more typical of the semi-subterranean dwelling. However, of the 14 houses whose depth is known, only three are more than 50 cm deep, indicating that deep pit houses may no longer have been used. It may be that the local populace no longer wanted or could afford to put the time and effort into the construction of deeper pits, and was content with shallower, less permanent construction. Two attributes of the Coyote Creek Phase houses support this interpretation (Table 14-5). The first is the nearly total lack of postholes which is most pronounced when compared with the Hudnut Phase where 37 postholes were recorded among 19 housepits. The lack of postholes, coupled with the shallowness of the structure, suggests a different form of superstructure than in either the Hudnut or Kartar Phases. Secondly, Coyote Creek houses have little indication of extensive re-occupation. Generally only a single floor was recorded and the density of material from the floor is much lower than the Hudnut Phase floors (with the exception of FMR; see Table 14-3). We take this to be evidence of a more transitory occupation; that is, a house might be occupied for a season or several seasons, but, unlike the Hudnut housepits, it is not re-occupied again and again over hundreds of years. The reasons for this are unknown.

Interior Features

Interior features are similar to those from the Hudnut Phase. A central hearth area is still the major source of heat and light; only one structure contains a second firepit. Structure 1 at 45-OK-287 has a smaller firepit near the structure's wall as well as the central hearth area, a pattern we first noted in the Kartar Phase.

Interior pits become scarcer in the Coyote Creek Phase. In House Z at 45-OK-2A, a small pit only 12 cm deep contained many fish bones, while in House 9, an interior pit was 1.2 m across and 40 cm deep. In Housepit 2 at 45-OK-258, an interior pit was nearly one meter in diameter and 85 cm deep. A small pit in the House 3 floor at 45-OK-2 contained a human cranium. Given

Table 14-5. Coyote Creek Phase housepits.

Site	Structure	Radiocarbon Date	Size	Depth	Shape	Walls	Floors	Firepits	Pits	Postholes
45-OK-2	House 2	1131±168	11.5 x 12.3 m rim	40 cm	Unknown	Unknown	1	1	-	-
	House 3	1112±95	10.5 x 11.5 m rim	-	Unknown	Unknown	1	1	1	2
	House 4	529±88	13.3 x 12.2 m rim	80 cm	Unknown	Unknown	1	1	-	-
	House 5	-	5.6 x 4.6 m	20 cm	Circular	Sloping	1	-	1	-
	House 6	<110B.P.	10 x 5 m	20 cm	Rectangular	Steep	1	2	1	1
	House A	-	Unknown	Unknown	Unknown	Unknown	1	-	-	-
	House E	196±70	8 x 6 m	Surface	Rectangular	None ?	1	3	-	-
	House F	227±80	8 m diameter	Surface	Circular	None ?	1	1	-	1
	House G	-	10 m diameter	40-50 cm	Circular	Sloping	1	-	-	-
	House L	1268±95	5 m diameter	75 cm	Circular	Steep	1	1	-	-
	House M	-	Unknown	50 cm	Unknown	Steep	-	1	-	2
	Structure N	839±68	3 x 2 m	30 cm	Oval	Steep	1	-	-	1
45-OK-2A	House 8	-	16.4 x 15.4 m rim	60 cm	Circular	Steep	1	-	1	-
	House 9	-	3.9 x 4.6 m rim	30 cm	Circular	Steep, Sloping	2+	-	-	-
	House Z	-	Unknown	30 cm	Unknown	Steep	1	-	1	-
45-OK-258	Housepit 2	-	7.5 m diameter	<40 cm	Circular	Sloping	1	1	1	-
45-OK-288	Structure 1	1046±69 1122±65	4.7 m diameter	35 cm	Circular	Sloping	1	2	-	-

our four examples, the reader can see that it is difficult to draw generalizations about interior pits in the Coyote Creek Phase. They seem to have been opportunistically constructed; that is, they were dug to suit the purpose at hand, but were not excavated on a regular basis or to specific proportions.

Three of the houses at 45-OK-2 have not been mentioned in the discussion so far--House 6, House E, and Structure F, which date to 1800-1830 A.D., 1850-1894 A.D., and 1650-1800 A.D., respectively. These three houses are completely different from the earlier houses discussed above. They are rectangular surface structures with either no walls or a short wall built up around the perimeter. House 6 even has an interior "wall" or rim of soil which sets off the eastern third of the house. Interior pits do not occur, but interior earth ovens--deep, rock-lined firepits--and more traditional hearth areas are present. Historic artifacts, carbonized layers of matting, FMR clusters and food processing areas have all been identified on the floors of these three structures. There is no readily apparent evolutionary line leading from the housepits of the Kartar Phase to the surface structures of the historic period at 45-OK-2, and it may be that the attributes which appear so quickly and unexpectedly here have their roots elsewhere.

EXTERIOR OCCUPATION SURFACES, FIREPITS, AND PITS

Exterior occupation surfaces, pits, and firepits are structured feature types. They have definable boundaries and regularly distributed contents setting them apart from debris scatters, a second category of exterior features to be discussed below. Also, these three feature types occasionally occur in association with each other, the two smaller features originating in the exterior occupation sufaces. Therefore, we consider these three feature types as a group.

EXTERIOR OCCUPATION SURFACES

These features are former land surfaces upon which evidence of **in situ** activity remains, with the surface itself being the primary criterion. A hardening of the soil or a change in the types of soil, verified by stratigraphers, constituted evidence of a surface. The types and intensity of activities recorded in these features is quite varied, as is their size. Other features of this type have been dubbed "activity areas" or "living surfaces;" our phrase was chosen to be neutral in terms of the number and types of functions the feature served.

One caveat is necessary: although these "exterior" surfaces have been placed into this category because there was no evidence of their being "interior" house floors, some of them may be just that. Some of the surfaces were recorded in isolated excavation units which may have come down in the middle of housepits and so revealed no walls. In other instances, the occupation surfaces occupied shallow depressions above older housepits; in these cases, no structural supports were in evidence but it is possible they were shallow surface structures. Both these scenarios apply particularly to

Hudnut Phase sites where the complex stratigraphy indicates long and varied site use above and below recorded housepits.

Kartar Phase

Looking first at the Kartar Phase, we find 17 occupation surfaces at three different sites; 14 are at 45-OK-11, and are coeval with the housepits there; two are in the rockshelter at 45-DO-326; and a large well-preserved example is at open site 45-OK-288. Four of these Kartar Phase occupation surfaces were excavated extensively and enough to gain a clear picture of the distribution of activities across the surface.

Two large occupation surfaces at 45-OK-11 were exposed in block excavations. Occupation Surface A, in Area 2, was seven meters across and occupied a very shallow (20 cm) depression, which apparently resulted from use, not from aboriginal digging. The surface could be divided into two parts: the central area, which contained two firepits, was darkly stained with charcoal and littered with debris. Shell, abundant in the firepits, was not plentiful on the surface itself. The periphery of the occcupation surface lay on the slope of the depression and held larger pieces of trash and a concentration of shell; it was deemed a disposal zone. Occupation Surface B in Area 3 also had a central and peripheral zone, with a chipping station of jasper flakes in the center and a scatter of large bone fragments and jasper flakes across a 5.5 m^2 area (the predominance of jasper on this surface was unusual given the high frequency of basalt and quartzite flakes in all other Kartar Phase features at 45-OK-11).

A third, large exterior occupation surface was excavated at 45-OK-288. Similar in age (4500 B.P.) to the other two, this confined area also showed a deliberate patterning of activities across it. Near a central, unprepared firepit were eight discrete clusters of small bone fragments. Pounding and cutting tools occurred around these bone clusters, and bitterbrush seeds were within the firepit. The season of use for this surface is suggested to be late spring and late summer. This occupation surface also occupies a shallow, non-excavated depression, as does a fourth large surface within the rockshelter at 45-DO-326. This last surface has some of the same attributes as the other three--central firepit, shallow depression, high density of materials--but any regular distribution of artifacts or activities has been obscured by several later large prehistoric pits.

When we compare the density and distribution of material in Kartar Phase housepits and exterior occupation surfaces, we note several similarities: the spatial arrangement of certain activities, associated firepits and pits, the densities of shell, FMR, stone and bone tools. There are, however, some notable differences. First, the density of bone is more than twice as great (by weight) on exterior surfaces, and bone fragments tend to be smaller. This suggests to us that meat processing was primarily an outdoor activity, with evidence of primary butchering recorded in bone scatters and further processing taking place in the multiple-use, exterior surfaces. Stone debitage is also more abundant on exterior surfaces than on housepit floors, and so knapping may have been more common as an outdoor activity as well. The formation of shallow depressions within the four major occupation surfaces and their definable boundaries further suggests that they may have been sheltered in some way, perhaps by a windbreak or a ramada, although no evidence of such structures has been found. However, we can think of no other reason why the outdoor activity areas would be so regularly distributed and confined.

Hudnut Phase

During the Hudnut Phase, the constant re-occupation and modification of sites or the rapid accumulation of natural strata or both precluded the development of well-formed, well-preserved activity areas. Although more are recorded from the Hudnut Phase than the preceding phase, none revealed the same patterning of materials and features. Few were large, although several were extensively excavated. Many of the recorded occupation surfaces occur in the depressions above Hudnut Phase housepits. We have speculated that some of these may have held temporary structures, but as with the Kartar Phase, have no real evidence to support this. There are 14 small postholes in the depression above Housepit 3 at 45-OK-258, but unfortunately, no corresponding occupation surface.

Lacking specific surfaces to describe in detail, we resort to generalizing about Hudnut Phase exterior surfaces from the density figures (Table 14-6). We find that Hudnut Phase housepit floors are much richer in bone than exterior surfaces, although the bone is about the same size. This, coupled with the high density of bone in interior pits and firepits, suggests that secondary meat processing has become an indoor as well as an outdoor activity during this period. In the Kartar Phase, bone density, measured by either weight or number, is higher in exterior occupation surfaces than in house floors (Table 14-7), while the reverse is true in the Hudnut Phase (Table 14-8). In the Coyote Creek Phase there is less difference between the density values for house floors and exterior occupation surfaces and the rank orders of the two reverse depending on whether count or weight is used as the density measure (Table 14-9).

Coyote Creek Phase

In the Coyote Creek Phase, few exterior occupation surfaces were identified. Site 45-DO-214, an open camp site, contains the best examples. They are all small, confined areas (less than 4 m in length, more often less than 2 m), littered with FMR, bone, cutting and pounding tools, and associated with pits and firepits. As in the Hudnut Phase, no specific pattern of activities could be discerned. Unlike the Hudnut or Kartar Phases, exterior occupation surfaces were rare at Coyote Creek housepit sites.

EXTERIOR FIREPITS

Formal differences in Kartar and Hudnut Phase exterior firepits are subtle but, we feel, reflect real changes in the way firepits were used. In both phases, firepits tend to be medium-sized (50-70 cm diameter) and shallow

Table 14-6. Density of material from exterior occupation surfaces, pits, and firepits by phase.

Feature Type	Phase	N	Vol m^3	Bone			Shell		FNR		Tools	Debitage	Deer/deer-sized Bone	Salmonid Bone
				N/m^3	gm/m^3	N/gm	Hinges/m^3	Total gm/m^3	N/m3	gm/m^3	N/m^3	N/m^3	NISP/m^3	NISP/m^3
Exterior Firepits	Karter	8	1.60	704	144	0.20	460	87	86	17259	5.5	70	12.0	0.0
	Hudnut	28	3.55	286	47	0.16	187	166	110	63307	6.0	56	1.4	4.5
	Coyote Creek	28	4.75	333	118	0.35	7	8	276	176396	4.0	63	6.0	42.0
Exterior Pits	Karter	17	3.80	240	32	0.13	11	88	8	3780	3.0	26	1.0	0.5
	Hudnut	22	3.90	482	233	0.48	1090	77	20	5778	7.0	22	8.6	61.0
	Coyote Creek	15	3.69	1580	423	0.26	560	143	70	28517	5.0	56	11.1	28.0
Exterior Occupation Surfaces	Karter	17	24.40	2052	890	0.34	355	1322	46	7847	10.0	234	40.0	1.0
	Hudnut	28	21.06	2697	712	0.26	359	727	96	21625	7.6	159	39.0	10.0
	Coyote Creek	9	2.16	1441	502	0.34	456	1266	292	121328	13.0	214	28.0	0.0

Table 14-7. Ranking of feature types by material density, Kartar Phase.

Measure	Ranking										
	1	2	3	4	5	6	7	8	9	10	11
Bone N/m^3	2-3000 Bone S Ext OS	700 Ext FP	600 Fill Floor	500 Stratum Shell C Int FP	400 Stratum	300 Debris C	200 Ext Pit Int P	100 Stain	10 FMR		
Bone gm/m^3	5000 Bone C	800 Ext OS	300 Shell C	200 Floor Stain Wall	150 Int FP Fill Int Pit	100 Ext FP Stratum Debris C	10 Ext Pit FMR C				
Bone gm/N	>1.0 Bone C Stain	>0.5 Int Pit Shell C	0.4 Floor Wall	0.3 In FP Ext OS Debris C Fill	0.2 Stratum Ext FP	0.1 Ext Pit					
Shell hinges n/m^3	8000+ Shell C	2500+ Wall	500 Int Pit	400 Floor Ext FP	300 Stain Ext OS	200 Fill Int FP Bone C	<25 Debris C Ext Pit Stratum				
Total shell gm/m^3	12,000 Wall	4000 Int Pit	3000 Shell C Stain	2000 Floor	1000 Int FP Ext OS Fill	900 Bone C	200 Ext Pit	90 Ext FP			
FMR N/m^3	100+ Int FP FMR C Stratum	80 Ext FP	70 Shell C	40 Ext OS Stain Floor Wall	20 Bone C	10 Ext Pit Fill Int Pit	5 Debris C				
FMR kg/m^3	200+ FMR C	30 Int FP	20 Stratum	10+ Ext FP Shell C	8 Ext Pit	8 Ext OS	7 Stain Floor	5 Wall	4 Int Pit	3 Bone C	<2 Fill Debris C
Debitage N/m^3	200+ Ext OS	100+ Stratum	80 Int FP	70 Bone C Wall	60 Floor Ext FP Fill	50 Shell C	20 Int Pit	10 Stain Ext Pit	<10 Debris C		
Tools N/m^3	>10 Bone C Int FP Ext OS	>5 Stratum Ext Pit Floor Ext FP	≤5 Shell C Wall Fill Int Pit								

Table 14-8. Ranking of feature types by material density, Hudnut Phase.

Measure	Ranking							
	1	2	3	4	5	6	7	8
Bone N/m^3	9000+ Debris C	4000+ Int FP Floor	2000+ Ext OS Bone C	1900 Int Pit	500 PM	400 Ext Pit FMR C	300 Shell C Fill	200 Ext FP
Bone gm/m^3	2000 Debris C	1400 Bone C	1100 Floor Int FP	900 Int Pit	700 Ext OS	300 Ext Pit Shell C	100 PM FMR C	<100 Ext FP
Bone gm/N	0.74 Bone C	0.58 Shell C	0.4 Ext Pit Int Pit	0.26-.29 Floor FMR C PM Ext OS	0.22-.23 Int FP Fill Debris C	0.16 Ext FP		
Shell hinges N/m^3	3000+ Debris C Shell C	1000+ Ext Pit	700 Int FP	300 Floor Ext OS	100 Ext FP Int Pit	<65 Bone C FMR C Fill PM		
Total shell gm/m^3	5000+ Shell C Debris C?	1000+ Int FP Floor	700-300 Ext OS Int Pit	100 Ext FP Bone C Fill	<90 FMR C Ext Pit PM			
FMR N/m^3	~200 Debris C Int FP FMR C	~100 Ext FP Ext OS Floor	<55 Shell C Bone C Int Pit	<20 Ext Pit Fill PM				
FMR kg/m^3	686 Int FP	40-60 Ext FP FMR C	20-37 Debris C Ext OS	10 Floor PM	8 Shell C Int Pit	<6 Bone C Ext Pit Fill		
Debitage N/m^3	200+ Int Pit Debris C Floor	100+ Int FP Ext OS Bone C	<90 FMR C Fill Ext FP	<35 Shell C Ext Pit PM				
Tools N/m^3	21 Int Pit Debris	12-14 Floors Int FP Bone C	6-7 Ext OS Ext Pit Ext FP	5 Shell C FMR C	<3 Fill PM			

Table 14-9. Ranking of feature types by material density, Coyote Creek Phase.

Measure	Ranking						
	1	2	3	4	5	6	7
Bone N/m^3	8000 Bone C	3000 Debris C	2000 Int FP Floor	1500 Ext Pit Ext OS	900 Shell C	600 Int Pit	<400 Fill Ext FP PM FMR
Bone gm/m^3	4000+ Bone C	~800 Debris Floor	400-500 Int FP Ext OS Ext Pit	300 Shell C	~100 Ext FP Fill FMR C	<60 Int Pit PM	
Bone gm/N	0.52 Bone C	0.38-.37 FMR C Shell C	0.36-.34 Ext FP Ext OS Floor	0.24-.26 Ext Pit Debris C Int FP	0.15 PM	0.09 Int Pit	
Shell hinges N/m^3	3000+ Shell C	900 Debris C	400-600 Ext Pit Ext OS	200 Bone C	~50 Floor Fill FMR C	<20 Int Pit Int FP Ext FP PM	
Total shell gm/m^3	12,000 Shell C	1-2000 Debris C Floor Ext OS	500 Bone C	100 Ext Pit	70 Fill	<20 Int Pit Ext FP Int FP PM FMR C	
FMR N/m^3	300 FMR C	200 Ext OS Ext FP Int FP	100 Debris Floor Bone C	70 Ext Pit	55 Shell C	<20 Fill Int Pit PM	
FMR kg/m^3	120 Ext FP Ext OS	84 FMR C	64 Int FP	28 Floor Ext Pit	9-17 Debris C Bone C Shell C	<2 Fill Int Pit PM	
Debitage N/m^3	400 Int FP	200 Bone C Floor Ext OS Debris C	100 FMR C	<80 Fill Ext FP Ext Pit	20 Shell C Int Pit	1 PM	
Tools n/m^3	16+ Debris C Int FP Floor	13 Ext OS	<6 Shell C FMR C Ext Pit	- Bone C Fill Int Pit PM			

(less than 25 cm deep), but, as we have noted, material density, especially of bone, is higher in the Kartar Phase (Table 14-6). Possible reasons for this difference include small sample size and differential preservation; however, less intensive or extensive use of the Hudnut Phase exterior firepits is also a possibility. Five of the eight Kartar Phase firepits occur at 45-OK-11 and are thus associated with long-term housepit occupations; most of the Hudnut Phase firepits, however, were found at temporary campsites and may not have had recurrent use.

A major formal distinction in firepits is the advent of the rock-filled earth oven in the Coyote Creek Phase. Ten "ovens", defined as "pits used to cook food or heat other materials with trapped heat", were identified at 45-OK-2 (Campbell 1984a). Not all were rock-filled; some still contained their layers of fuel as well. Some even occurred within housepits. Some of the ovens at 45-OK-2 date to the Hudnut Phase, and large cooking pits dating to that period have been found at other sites as well (e.g., 45-DO-242). On the other hand, rock-filled ovens at the project are confined to Coyote Creek Phase assemblages. Of the examples recorded at 45-OK-2, 45-DO-214, and 45-DO-204 some may be as old as 1200 B.P., but only one (at 45-DO-204) has been directly dated to 5-600 B.P. They are circular, about a meter in diameter, and up to 35 cm deep. However, an earth oven from 45-OK-208 in the RM 590 area is radiocarbon dated at 2465±200 (dendrocorrected date, Table D-4, Appendix D; see Chatters 1984:A121 for description of feature and original date). In general, Coyote Creek Phase firepits tend to be much larger (ca. 1 m diameter) than earlier firepits and are filled with FMR (note high density of FMR in Coyote Creek exterior firepits in Table 14-6); it may be that many of them are poorly preserved ovens.

EXTERIOR PITS

Exterior pits occur at both habitation and camp sites in all three phases. There seems to be little change in form in these pits through time, despite some indications to the contrary. For example, it appears that Kartar Phase pits are smaller than those of succeeding phases (those at 45-OK-11 and 45-OK-288 are usually less than 50 cm in diameter), until the very large, bell-shaped pits in the rockshelter at 45-DO-326 are included. Hudnut Phase pits also might be considered small, when the total number and volume are taken into account (Table 14-6). However, so many Hudnut Phase pits were incompletely excavated or poorly preserved that only a portion of each has been recorded. Thus, apparently distinctive attributes of exterior pits in each phase are not so distinctive on closer scrutiny.

Seventeen pits were recorded at three Kartar Phase sites. Those at 45-OK-11 and 45-OK-287 are generally small and between 20-30 cm deep. The function of these pits is unknown; they are filled with camp trash. Some may have been used for cooking or heating, but not enough evidence remains to label them "firepits." The seven pits at the rockshelter, 45-DO-326, are very different from those at the other two sites. These pits were a meter or more in diameter and 50-75 cm deep. They were straight-sided, bell- or basin-shaped in form, and contained primarily bone scrap and other debris from the occupation surfaces which surrounded them. They cut into each other and were cut into, in turn, by later Hudnut Phase pits of similar size, form, and fill. However, even though one might hope that such pits would be filled with material, we find that Kartar Phase exterior pits contain much less material than pits of succeeding phases.

Twenty-two exterior pits were recorded at seven Hudnut Phase sites, most at habitation sites contemporaneous with housepit occupations. There is a great deal of variation in pit size during this period: some are around 50 cm in diameter (45-55 cm), but most are between 90 and 130 cm across, and from 55-80 cm deep. Only two of the large pits occur in the rockshelter (45-DO-326); others, at 45-DO-211, 45-OK-250, and 45-OK-4, are associated with housepit occupations. Several large pits, which may have been cooking pits, were recorded in the fill above Hudnut Phase housepits at 45-DO-242. The exact function of the Hudnut Phase pits is obscured by later fill or poor preservation, but a variety of functions appear to have been served. The pits at 45-DO-242, for example, each contained several overlapping, smaller, carbon- and debris-filled pits (several recorded under a single feature number), while at 45-DO-326, only general trash was lightly scattered through the pit fill. Several pits at 45-OK-258, 45-OK-4, and 45-DO-211 contained many salmon bones and, occasionally, an articulated, nearly complete salmon skeleton, while other pits at the same sites contained no fish bone. Shell, in the form of hinge pieces, is also a major constituent of the Hudnut Phase pits. Thus it appears that there may be some differences in function or intensity of use between the Kartar and Hudnut Phases, even though we cannot say exactly what those functions were.

Seven Coyote Creek sites yielded a total of fifteen exterior pits. Again variety is the key word in describing size, shape, and contents. The pits range from a small, shallow cache of bone and stone tools (some fishing implemants) at 45-DO-214 to large (1 m plus), deep (70 cm) pits at 45-OK-2 and 45-OK-258. As with the Hudnut Phase, the larger pits are more frequent. Unlike Hudnut Phase pits, the Coyote Creek Phase pits contain a great deal of bone scrap and FMR. Salmon appears in high frequencies, although less than in the preceding phase (Table 14-6). Campbell's conclusion that pits at 45-OK-2 contain "no evidence of any other function beside storage," should apply only to interior pits since the contents of exterior pits imply meat processing or cooking.

DEBRIS CONCENTRATIONS/SCATTERS

We use the labels debris concentration or debris scatter for unstructured features characterized by unusually high density or isolation of particular categories of material. As discussed in the research design (Campbell 1984b), the labels **concentration** and **scatter** are not contradictory. Concentration indicates the high density of material, relative to the surrounding matrix. Scatter indicates that the spatial arrangement of the debris is random. Each kind of debris scatter can vary from very limited concentrations of a few pieces to thick midden deposits. Because debris scatters are unstructured, they lack standard forms or patterning diagnostic of temporal phases.

However, the frequency, contents, and associations of debris scatters in sites of different ages would be a fruitful avenue for further research. Table 14-10 presents measures of debris scatter contents by phase; however, we restrict our discussion to pointing out a few trends and biases in the data.

First, biases in the debris scatter data are created by the excavation of "content features." A content feature was defined when an unusual concentration of a specific type of material (bone, FMR, less often shell) was encountered within a unit level. Those artifacts, and those artifacts alone, were removed and recorded as the feature. Other material collected from the pit or the screen was labelled as "unit level material" and considered separately. Thus, in a scatter of large bone, only the large bone would be collected as the feature; smaller pieces were bagged separately. This procedure has biased the mean weight tabulations for bone concentrations. In an FMR scatter, only FMR would be collected and other material would be recorded elsewhere, thus decreasing the density measurements of other material types in FMR scatters. This approach was an exception rather than the rule, and was applied more often to FMR scatters than to other types of features.

One well-preserved, dense bone scatter is recorded in each of the three phases: Kartar Phase at 45-OK-11, Hudnut Phase at 45-DO-242, and Coyote Creek Phase at 45-OK-258. In each of these, large bone predominates with pockets of crushed bone occurring as well. Deer is by far the most abundant species with mountain sheep and pronghorn, as well as other large game, occasionally represented. Each of these three large bone scatters (from 4 to 8 m across) is associated with a housepit occupation at the site. The extremely large average bone weight noted for the Kartar Phase (Table 14-10) stems from the bias discussed above. Also the high density of tools for the Kartar Phase reflects the fact that the bone scatter at 45-OK-11 was a primary butchering area (the distribution of the bone and staining of the soil support this contention), while the large Coyote Creek bone layer at 45-OK-258 is thought to be a dump.

FMR scatters are more frequent and denser in the Coyote Creek Phase (Table 14-10). This repeats the trend seen in other exterior features where FMR abundance increases dramatically in the Coyote Creek phase; the reasons for this trend are not clear. Again, the biases discussed above make density measurements of materials associated with FMR scatters unreliable; FMR density is overestimated and density of other materials underestimated.

SUMMARY

We noted in our descriptions of the feature types certain changes in the organization of activities on the site through time; these changes occur for the most part between the Kartar and Hudnut Phases.

Limited evidence from 45-OK-11 suggests at least two families or an extended family within the dwelling, with activities focused around two or more firepits and pits. Primary butchering of meat occurred at the exterior bone scatters with secondary processing on exterior occupation surfaces. Shellfish, wherever processed, were dumped in large exterior middens and scatters; shell was used occasionally to line housepit walls and

Table 14-10. Density of material from exterior debris scatters by phase.

Feature Type	Phase	N	Vol m^3	Bone			Shell		FMR		Tools	Debitage	Deer/deer-sized Bone	Salmonid Bone
				N/m^3	gm/m^3	N/gm	Hinges/m^3	Total gm/m^3	N/m^3	gm/m^3	N/m^3	N/m^3	NISP/m^3	NISP/m^3
Bone Scatters	Karter	4	1.49	3232	5115	1.6	206	927	26	3824	14.7	79	220.0	0.0
	Hudnut	9	2.60	2123	1473	0.69	63	131	46	6013	12.0	100	127.0	1.5
	Coyote Creek	12	4.24	8864	4642	0.52	209	519	118	11115	4.0	283	438.0	1.6
FMR Scatters	Karter	1	0.10	10	20	0.2	0	0	150	211430	0.0	0	0.0	0.0
	Hudnut	15	5.96	471	141	0.29	48	90	194	48148	89.0	5	10.0	0.0
	Coyote Creek	31	8.60	226	87	0.38	28	?	324	84446	6.0	109	4.0	0.1
Shell Scatters	Karter	18	6.94	556	353	0.63	6152	3670	77	10708	5.0	55	6.0	0.14
	Hudnut	38	14.30	392	230	0.58	3203	5764	55	8711	5.0	32	15.0	1.1
	Coyote Creek	8	0.93	898	373	0.37	3035	12820	55	9428	6.0	25	14.0	13.0
Debris Scatters	Karter	2	0.80	354	110	0.31	22	?	5	650	0.0	7	1.3	0.0
	Hudnut	4	10.50	9125	2004	0.22	3810	3	239	37043	21.0	245	64.0	0.76
	Coyote Creek	4	9.10	3038	800	0.26	888	2023	173	17352	23.0	214	14.0	1.0

interior pits. The density of debitage on exterior occupation surfaces suggests that most reduction took place there, but interior firepits also were the center of much knapping activity. Tools fell into the archaeological record where they were being used or manufactured--bone scatters, interior firepits, exterior occupation surfaces. (See Tables 14-7, 8, and 9) for a ranking of feature types by density of material.) The point of this recitation is that, while activities of all types took place inside the dwelling, the bulk of the activity occurred outside.

The role of the pit dwelling within the system seems to expand from the Kartar to Hudnut Phase. Through slow shifts in degree, activities in the Hudnut Phase are organized quite differently than in the preceding phase. Many activities now take place primarily within the housepits themselves, if we can use the ranking of feature types (Tables 14-7, 8, and 9) as an indication (and recognizing the dangers and biases therein). Bone is particularly abundant on the housepit floors and in interior firepits. Only general debris scatters, a category heavily weighted by the dump stratum at 45-OK-250, consistently rank above interior features in material density. Secondly, the focus of activity within pit structures is a central hearth area, an unexcavated, possibly rock-ringed fireplace. No division of work or division into social groups such as families is evident in the Hudnut Phase housepit. Thirdly, in the Hudnut Phase, the housepit itself may have evolved a seasonal function. Groups of pit dwellings analogous to the ethnographic "winter" village have been recorded, but we also have evidence (see the discussion of the faunal remains in the 45-DO-211 housepits) of housepits occupied solely during the spring or summer fish runs, the subsurface equivalent of temporary shelters constructed by historic groups for their summer fish camps.

The Coyote Creek Phase is more difficult to characterize, since there are no distinctive shifts in the Hudnut to Coyote Creek Phase. Bone, debitage, and tools occur in highest density in interior features; shell and FMR in exterior featues. Rock-filled ovens appear. Shallow surface structures occur more frequently, culminating in the mat lodges of the protohistoric period. Although there is little evidence for re-occupation of Coyote Creek Phase housepits, their shallow nature and lack of elaborate superstructure suggest a cultural premium on mobility. Many of the feature types used in the Coyote Creek Phase are very similar to those of the Hudnut Phase (housepits, central hearth areas, large exterior cooking pits), but there are other formal differences (mat lodges, rectangular structures, rock-filled ovens) which suggest significant cultural changes in this last period of prehistoric occupation.

GENERAL INTERPRETATIONS OF PROJECT AREA PREHISTORY

Analysis and interpretation of features, particularly houses, has played a fundamental role in interpreting the organization of activities at all project sites. However, at no site has the role of features been more important than at 45-OK-11, which yielded the largest single assemblage of houses and other features dating to before 4500 B.P. on the Plateau. This unprecedented data base provides an opportunity for re-evaluating many previous interpretations of Plateau prehistory (Lohse 1984).

The interpretations of project area prehistory discussed here may not agree with those in other chapters; the differences are one of theoretical interpretation rather than disagreements about the prehistoric record. The perspective followed here is that presented in the final chapter of the 45-OK-11 report (Lohse 1984; see also Jaehnig and Lohse 1984). In this view, the cultural system is seen as responsive to a set of vectors, or directional forces, which create certain pressures to which the system must adapt. Although vectors need not necessarily be negative, most are seen by archaeologists as points of stress on or within a cultural system. Environment, demographics, ideology, technology all create problems (or opportunities) for a culture. Change results either when the culture adopts a new response to an existing challenge, or when one or more of the vectors change. A sudden increase in population density would be an example of the latter; a new group organization in the face of continued increasing density, an example of the former. Cultural adaptation is seen as gradual and continual.

The view that changes in economic strategy were gradual and due to various interacting vectors disagrees with the theories which link the emergence of semisedentism or the winter village with the sudden exploitation of either salmon (Nelson 1969), root crops (Ames and Marshall 1980), or storage (Schalk and Cleveland 1983). Such explanations are theoretically unsatisfying because they do not explain the emergence of the technology or strategy upon which the development of villages is supposedly dependent; more tellingly, our data do not support any of them. To summarize the argument made in detail by Lohse (1984) we have a body of data which indicates that no single attribute can be called upon to explain the establishment of the village pattern across the entire Plateau and that villages have existed upon the Plateau for the last 5000 years. Our most telling argument against the sudden emergence of winter villages around 3000 years ago is 45-OK-11, a large village site of 13 housepits (estimated 3-5 contemporaneous), occupied at points between 5500 and 4500 B.P. Our evidence against the three specific attributes usually cited as seminal in the development of villages comes from features, fauna, and artifact assemblages. Fishing, root processing, and storage are all represented in the project area from our earliest sites through the most recent. Granted, there does seem to be increasing dependence on some resources (e.g., salmon in the Hudnut Phase) and innovations in technology (e.g. the rock-filled ovens of the Coyote Creek Phase), but we view these, not as the sudden introduction of a resource, but as the gradual emphasis of a resource already in the repertoire; and occasional innovations of form do not neccessarily indicate a concomitant innovation of function.

What then do the innovations and changing emphases in feature form indicate? I believe, and here I differ from viewpoints expressed elsewhere in this volume, that two negative vectors were simultaneously acting upon the late Kartar Phase groups in the area. The first vector is the possible declining productivity of the shell beds, a resource upon which the occupants of 45-OK-11 drew heavily. However, other than some indications of increased river flow and lateral movement of the river in the late Kartar Phase (see

Chatters 1984) which may have affected shellfish abundance, I have no empirical means of corroborating or refuting this suggestion so I will not dwell on it as a possible directional force.

The second vector, for which there is ample evidence, is increasing population density from the Kartar to the Hudnut Phase. In his discussion of site clusters, Salo (Chapter 8) notes two clusters of habitation and camp sites in the Kartar Phase, widely separated along the river. Four such clusters, overlapping in age, occur in the Hudnut Phase. Density measurements and the evidence of multiple floors and several superposed pit structures indicate frequent re-occupation and intensive use of Hudnut habitation sites, much more so than in Kartar habitation sites. This evidence of more site clusters, frequent re-occupation and high material density suggests the following interpretation. The success of human habitation in the area, as evidenced by the establishment of the 45-OK-11 village around 5000 years ago, was accompanied by increases in population. As group size reached maximum limits for the social structure and supporting resources and technology, new groups budded off into previously unoccupied areas, such as the left bank (southern or Douglas County side) of the Columbia River. Others have suggested that the opening of the left bank habitation sites (45-DO-211, 45-DO-242, etc.) is due to the improvement of the local environment which allowed the previously "marginal" area to be settled. My argument is that increasing population pressure led to the settlement of new areas whether they had "improved" or not. Because new groups had formed, each with its own territory of habitation and camp sites, sites were re-used more frequently as groups moved within increasingly restricted territorial ranges.

The above argument is based on the view that population increase is a natural result of a successful system that has not yet reached its environmental limits. Once the population has reached the limits of the environment and/or cultural system, either 1) growth is limited; 2) new technologies/strategies evolve; or, 3) new social organizations develop. It is a combination of the last two factors that is responsible for the differences between the Kartar and Hudnut Phases.

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SECTION V: SYNTHESIS

Schalk and Cleveland (1983) review the archaeological literature for the Columbia Plateau and present a 3-stage model of prehistoric subsistence systems that emphasizes organizational change. The first stage, broad spectrum foraging, is characterized by highly mobile groups with a generalized resource base that varies with local resource abundance, and a generalized tool kit that varies little from site to site. After thousands of years, this adaptation is replaced by a semisedentary adaptation, signalled by the appearance of winter pithouse residences. These indicate an organizational change in which storage replaces hunting as the primary over-wintering strategy and residential mobility is severely decreased. No other major organizational change occurs except for the development of a mobile foraging strategy based on horses in some areas of the Plateau after 1700 A.D.

The archaeological record from the project area is clearly attributable almost entirely to Schalk and Cleveland's semisedentary stage. Schalk and Cleveland assume that the semisedentary adaptation appears around 3-4000 B.P., while we have evidence of it at 5100 B.P. Although the extreme ends of the occupation span may represent the other stages of their model, the scale of our analysis does not allow us to examine these separately. Because the earliest housepit is 5200-5100 B.P., the first part of the Kartar Phase may not fit this adaptational pattern. Future analysis might well contrast this earlier period with the later Kartar. Likewise, the impact of the horse probably was felt in the project area even if less than in other areas of the Plateau; however, our analysis is not in short enough time periods to look at this separately.

Schalk and Cleveland state a caveat related to the use of stage models; the stage model is imposed on what is actually a record of continuous change and long-term processes. Here the project's research in Rufus Woods Lake can make a contribution. The archaeological record of this area offers excellent potential for examining the nature and processes of change within one stage of their model, the semisedentary adaptation. Indeed, this preliminary summary of results indicates substantial, regular variation in the organization and structure of prehistoric cultural activities through 6,000 years of semisedentary adaptation, variation that cannot be explained simply by changes in local resources and environments.

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15. DISCUSSION AND CONCLUSIONS

by Sarah K. Campbell

The most general outlines of prehistoric occupation of the project area offer little surprise as they are consistent with what is known from other areas of the Plateau. Stylistic evidence suggests that human occupation of the project area began around 6500 B.P., although the earliest radiocarbon date (dendrocorrected) is 5400 B.P. Occupation of the riverine zone was continuous into historic times. Throughout the span of occupation, populations supported themselves with a hunting and gathering mode of subsistence utilizing local resources such as artiodactyls, small mammals, fish, fruits, and roots. Locally available woods, lithic materials, bone, and antler were used for fashioning artifacts, supplemented by imported shells and exotic lithic materials. Substantial dwellings were constructed from at least 5100 B.P. on, and various specialized features were built for processing, storing, and cooking food. When European goods became available, they were incorporated into the material culture gradually.

Some previous studies of Plateau prehistory, based on smaller samples with more temporal discontinuities and fewer occupations representing each period, have emphasized contrasts between assemblages of different ages. We also discuss differences, but this large, systematically collected data base provides compelling evidence for continuity of cultural patterns through time and the general subtlety of change. Most temporal differences we observe in the prehistoric record are matters of degree, e.g. a decrease in the relative frequency of basalt projectile points or an increasing predominance of a few taxa among the faunal remains. Some quantitative differences, however, are so large in magnitude, or happen so rapidly, that they have the appearance of qualitative changes. For example, there is a large increase in the number of sites and total amount of cultural material after 4000 B.P. The Kartar Phase is distinguished by greater abundance and diversity of cobble tools than later assemblages, more use of basalt in making flake tools, and a microblade industry. Pithouses are more widely and evenly distributed during the Hudnut period, the only time they are found on the south side of the river. The remains of shellfish are abundant at Kartar and Hudnut Phase sites but decrease to negligible amounts during the Coyote Creek period.

Similar observations previously have been made about the prehistoric record in other regions of the Plateau; nonetheless we make a contribution in several ways. First, the project report series provides systematic empirical documentation for our generalizations. Previous syntheses have not commonly provided detailed tabulations of data to support descriptive generalizations. Secondly, we have used Binford's concepts of foraging versus collecting strategies (Binford 1980) as an organizing device for interpretation, linking this work to general theoretical issues and to other regional research (e.g., Chatters 1984a). It is possible to evaluate the significance of subtle quantitative changes such as we observe only with respect to such a theoretical framework. Finally, we are in a position to demonstrate the complex structure of the Plateau riverine archaeological record and to emphasize the importance of developing creative strategies for studying this record in ways meaningful for interpreting the cultural system as a whole.

The first few sections of this chapter summarize the general parameters of the archaeological record, especially systematic comparisons between phases. This is followed by a section summarizing the economic strategy of each phase, with details on individual sites. This leads to a consideration of the biases affecting our interpretation of the prehistoric record and to a discussion of the mechanisms involved in evolution of logistical systems.

OCCUPATION SPAN AND SITE FREQUENCY

In order to roughly estimate population levels we examined the frequency of components through time in four ways: using frequency of radiocarbon dates in absolute time, and using numbers of components by 500 yr, 1000 yr, and 2000 yr intervals.

The frequency of radiocarbon dates by time (Salo, Chapter 6) suggests possible population fluctuations throughout the occupation span. Minima occur around 4000 and 2000 B.P. Similar results are obtained when components are tabulated by 500 yr intervals (Miss, Chapter 9); this distribution has minima between 4500 and 4000 B.P. and 2000 and 1500 B.P. When 1000 yr intervals are used, however, the frequency of components forms a unimodal curve. The frequency of components by phase (Salo, Chapter 6) shows yet another pattern. There are approximately twice as many sites in the Hudnut period as in the Kartar period. This could indicate a doubling of the population or a shift in settlement pattern so that a greater proportion of sites are located within the project boundaries. The number of sites increases slightly in the Coyote Creek Phase. The general increase through time indicated in the phase analysis masks the minima and the drop-off in number of sites noted in the 500 and 1000 yr interval tabulations. A relatively low number of sites prior to 4000 B.P. is indicated by all the analyses, and the shorter intervals and radiocarbon curves indicate rapid increase after 4000 B.P.

Factors other than prehistoric population size or settlement pattern may partially account for the scarcity of components in the early period. Salo attributes the low numbers of radiocarbon dates to generally poor organic preservation in these sites on long stable surfaces. Removal of charcoal, and possibly other light materials by river deflation is most likely responsible for the absence of charcoal at sites like 45-DO-282 and 45-DO-273. However, organic preservation was not a problem at 45-OK-11, where charcoal was relatively abundant and delicate organic tissues were preserved. At any rate, the number of components is low even when components dated stylistically rather than by radiocarbon dates are included.

Geological processes are probable contributing factors. The older the land surface, the greater the chance that it would have been affected by erosion, destroying or reworking the site, or by burial, covering the site so there is no surface indication. Although many buried sites were found by exposure in recent erosional cuts, the older sites may be buried further back in fans and terraces and would not be exposed as often. Also, as we know that many land surfaces in the reservoir are recent, older sites may be found primarily on older, higher terraces not included within the guide-taking lines. Nonetheless, older sites are found on low terraces, and preservation can be quite good in older sites, as witnessed by 45-OK-11. The nature and extent of biases in this early period can only be established by further research, particularly geomorphological reconstruction. For the purposes of this discussion, we assume that the low number of early sites in our sample is a valid representation of the archaeological record of the riverine area.

Salo attributes lower numbers of radiocarbon dates at the recent end of the scale (post-150 B.P.) to problems of radiocarbon dating recent samples. This and a lack of interest in dating late sites, particularly if they can be dated by trade goods may be contributing factors; however, the total number of components also declines after 1000 B.P. (see Figure 9-2, 9-3). Because of the association between age of sites and age of land surfaces, and thus elevation (Chapter 5), we are reasonably certain that proportionally more late than early sites were inundated by the reservoir. The degree to which these biases operate should be examined more thoroughly because of the possibility of population decline due to epidemic disease, which could have been introduced as early as the seventeenth century.

SITE DISTRIBUTION

Leeds (Chapter 7) derives expectations for site distribution and site type differentiation by applying an hypothesized hunter-gatherer subsistence strategy to the environmental structure of the project area. The prehistoric inhabitants of the area had a logistically organized production strategy (Binford 1980) and it seems this pattern may be as old as 5000 B.P., as indicated by 45-OK-11, a housepit village of this age. Assuming that housepits are the remains of winter villages, the focus of long-term storage, the expectation is that the winter village location will be selected to minimize the trip distance to the critical resources least evenly distributed. Binford (1980) suggested that the distance minimized will be the distance to resource with the greatest bulk demand. Leeds proposes alternatively that winter village location will be determined by ranked, or hierarchical factors. The distribution of open camps and nonhabitation sites will be determined by a different set of environmental factors than the housepit sites.

The expected distributions are found in the project data. Using several statistical techniques, Leeds evaluates the nature and significance of the distribution of sites along the river. Housepit sites are clustered at many scales, distribution becoming random only at a scale of one mile or less. The distribution of open camp sites below one mile, however, is uniform, suggesting dispersion due to competition or local depletion of resources.

In the second part of the study, multiple regression analyses were performed between site locations and a number of "siting factors", or environmental variables expected to influence site location, such as solar exposure, steepness, and area of various vegetation communities, compiled by one-mile reach. On the Okanogan County side, 52% of the variance in housepit site locations was explained by five siting factors; indices for environmental diversity, draws, bluffs, amount of rock, and amount of solar exposure. The distributions of open camp sites differ on the two banks of the river, and are explained by variables that contrast with those explaining housepit location. Much less of the variance in open camp distributions can be explained by the siting factors used in the study. On the Douglas County side seven variables explain 24% of the variance; the first three variables being indices for environmental diversity, bluffs, and broadleaf communities. The indices expressing amounts of pine forest, solar radiation, and draws explain 20% of the variance in open camp locations on the Okanogan side. Nonhabitation sites on the Okanogan side match the distribution of the Type 1 sites, while on the Douglas County side the first factor is rapids.

Salo (Chapter 8) extends the distributional study using three types of habitation sites and contrasting the patterning of site location by phase. He suggests site clusters defined by modalities in site distribution (at scales found by Leeds to be nonrandom) as surrogates for communities.

The greatest contrasts are found between the Kartar and Hudnut Phases. The Kartar sites formed only two clusters, and both later phases have four clusters. The Kartar period "community territory" thus appears to be twice as large as that in Hudnut and the site density is only half. The Kartar Phase clusters are focused around Hopkins Canyon and Belvedere, areas that we believe provided the best winter range in the project area for ungulates. The Hudnut Phase clusters are focused on the Hudnut Canyon and Belvedere areas. Hudnut period housepit sites are more evenly distributed than in any other phase; this is the only period during which housepits are found on the Douglas County side of the river. In the Coyote Creek period, housepit sites are again restricted to the north bank and seem to be clustered around the Nespelem River, a notable fishing area.

SITE TYPES AND CONTENTS

Selecting criteria applicable to the project data set, Salo (Chapter 6) defined site types intended to correspond with the site types defined by Binford (1980) for logistical and foraging systems. Type 1 sites have a house and at least one other structured feature; they are surrogates for residential bases. Type 2 sites have a living floor or midden and one other structured feature; they are surrogates for field camps. Type 3 sites have one or no features; they are surrogates for stations and locations. Salo also outlines contrasting expectations for the types in logistical and foraging systems.

TEMPORAL DISTRIBUTION

Miss (Chapter 9) shows that residential bases (Type 1 sites) increase in number from 5000 B.P. to 2000 B.P. and are the most common site type between 2000 and 3000 B.P. The number of field camp (Type 2) sites increases through time until after 2000 B.P. they are more common than Type 1 sites. The number of locations/stations (Type 3 sites) is fairly constant except for a drop in the latest period (200-1000 B.P.). The three site types are fairly evenly represented in Hudnut and Coyote Creek and least evenly represented in Kartar, where there is a predominance of Type 3 sites.

GENERAL DEBRIS CATEGORIES

Miss (Chapter 9) examines the quantities of cultural refuse through time, in terms of both density and rate of accumulation. The mean densities and mean rates of accumulation of all materials--lithics, bone, shell, and FMR--form strongly unimodal distributions centering on 2-3000 B.P. Residential sites (Type 1) consistently have the highest densities of all material categories, and the highest mean rates of accumulation, except for lithics, which have the highest mean rate of accumulation in stations/locations (Type 3 sites) and the lowest in residential bases. After 2000 B.P. the rates of accumulation of lithics, bone, and FMR increase at field camp (Type 2) sites.

ARTIFACTS

Salo (Chapter 6) develops expectations for representation of functional artifact type at different site types. He expects decreasing richness and evenness of functional type assemblages from residential bases to field camps to stations/locations. This seems to be the case but sample size cannot be ruled out as an explanation. This question may be answerable by plotting separate diversity curves for Types 1, 2, and 3 sites and comparing them. If the types are simply arbitrary divisions of a total continuum of site densities, then the curves should be the same. Otherwise, new classes should be added at different rates.

There are significant differences among the site types with respect to inventories of functional types. Large stone tools and flaking debris are represented in highest proportions in residential bases (Type 1 sites). Type 1 sites have similar inventories throughout except for the greater number of cobble tools in Kartar. Field camps (Type 2 sites) differ little between Coyote Creek and Hudnut Phases and are virtually absent in Kartar. Kartar Phase stations/locations (Type 3 sites) are significantly different than those of the two later phases in ways that cannot be attributed to change from cobble tools to flake utility tools (higher proportions of carving, sawing, drilling, hard and soft scraping tools); this implies a different economic system in Kartar.

Campbell (Chapter 10) examines technological variation among site types and phases for evidence of specialization of lithic industries. It is assumed that in a generalist and expedient strategy of lithic manufacture, materials would be used in proportion to their occurrence in the environment, and would be modified as little as possible. The more that materials are selected disproportionately and curated, and the more energy invested in modification, the more specialized the lithic manufacturing system.

A relative increase of cryptocrystalline siliceous (CCS) materials and decrease of basalt and quartzite for flake tools is apparent at all site types except Type 3 sites, where higher proportions of CCS occur in Kartar than in Hudnut. There are several possible reasons for increasing proportions of CCS materials: 1) the catchment area for food resources decreased so that access to some lithic resources was curtailed; 2) the Kartar knappers worked non-CCS materials because to make projectile points they needed large flakes and blades not easily obtained from available CCS resources; or 3) local non-CCS lithic resources were gradually exhausted by human use.

Proportions of material types among flake tools alone also were examined as an indication of the degree of selectivity being practiced. In the Hudnut and Coyote Creek Phases, the use of lithic materials was most even in Type 3 sites and least even in Type 1 sites. The Kartar Phase pattern differs; the greatest dominance of CCS, and thus the least even distribution, was found at Type 3 sites. The Kartar Type 3 sites were evidently the scene of relatively specialized lithic manufacture, indicated as well by the strong association of a microblade industry with these sites. When the distribution of flake tool categories (shaped, retouched, and worn only) was examined for CCS alone, the highest proportions of shaped tools were found at Type 1 sites and the highest proportions of utilized-only flakes at Type 3 sites in all phases.

Lohse's analysis of neck widths and haft element widths (Chapter 11) indicates the adoption of a new technology, probably the bow and arrow, at or just prior to 2000 B.P., although wide-necked point styles such as Quilomene Bar Corner-notched and Basal-notched may indicate continued use of the atlatl as well. The interpretation of these point types as atlatl tips is supported by the similarity of their breakage patterns to those of earlier point types assumed to be atlatl points.

FAUNA

Following Binford's (1980) arguments, stations in a logistical system should have fairly specialized resource inventories because they represent actual procurement locations. Field camps also should be fairly specialized as they are set up to maximize access to particular resources. Salo (Chapter 6) suggests that in a logistical system faunal assemblages at Type 1 sites would be moderately rich, and have low to moderately even distributions among taxa. At Type 2 sites, richness and evenness would be higher, and assemblages at Type 3 sites would be least rich and even.

The data do not fit this model entirely (Table 15-1). Type 1 sites have the least evenness in all phases, and Type 2 and Type 3 sites are virtually identical in evenness in each phase (evenness could not be calculated for Kartar Type 2 sites). Looking at the faunal assemblages of the phases in their entirety we note that evenness decreases from Kartar to Coyote Creek, a trend apparent for each site type. The highest richness is at residential bases and lowest at stations, however, this also matches the trend in sample size, so is not necessarily a culturally determined pattern.

Table 15-1. Evenness of faunal assemblage by site type and phase.

Phase	Site Type			
	Type 1	Type 2	Type 3	All
Coyote Creek	132	83	82	120
Hudnut	103	78	80	103
Kartar	77	–	68	68
All	103	72	73	

1. Index of evenness is total of absolute difference between percent repesentation and expected percent if each category were equally represented. Calculated from data in Table 6-16 using the following categories: large herbivore, small herbivore, carnivore, turtle, salmonid fish, nonsalmonid fish.

In each phase the highest proportions of small herbivores (economic species) and salmonids are found in Type 3 sites. The highest proportions of large mammals and non-salmonid fish are found in Type 1 sites (except for non-salmonid fish in Coyote Creek). It is particularly interesting that the relative proportions of the six grouped categories in Kartar period residential bases (Type 1 sites) are closer to those in Hudnut field camps (Type 2 sites) than other Kartar site types (see Table 6-16).

Shell is not included in a closed array with other faunal remains because the methods of quantification are not comparable. To compare among site types and phases, Salo (Chapter 6) used shell density (# of shells/volume of sediment). Using this measure, the total amount of shell deposited decreases through time. Shell is most common at residential (Type 1) sites, rare at locations/stations (Type 3 sites), and intermediate at field camp (Type 2) sites in all phases. Shell fragment size decreases through time.

The argument could be made that evenness in a strongly logistical system faunal assemblages should be highest at residential sites, where storage occurs, lowest at stations, and intermediate at field camps, which are established to specialize in a limited set of resources. Alternatively, the highest evenness might be found at field camps representing the early spring period of low productivity. During this time, stored foods may have been exhausted, and there are no high bulk resources available.

The examination of data on season of death of artiodactyls of known age by Livingston (Chapter 12) had interesting and useful results. Availability of multiple samples from different sites, with varying sample sizes, provided insights into interpretation of seasonality not previously obtained in Plateau archaeology. In the project samples of aged artiodactyls, increasing the number of individuals in the sample expands the range of seasons indicated, until the entire year is represented. Clearly the range of seasons is highly linked to sample size, and inferences of season of site occupation from small samples are suspect. Although the distributions of seasons can not be used to infer the season of occupation, it can be used to ascertain the intensity of hunting in different seasons. In most of the large samples from pithouses, the estimated deaths range the entire year, but the greatest frequencies are in the winter months, indicating that most of the hunting from that site was done during the winter and that hunting was a less frequent activity during the remainder of the year, or at least at this location. The one exception to the winter hunting pattern is 45-OK-4, where the greatest number of aged individuals died in the spring months.

BOTANICAL REMAINS

Because botanical remains were not examined from all sites, nor randomly sampled within sites, we cannot systematically compare the cultural use of floral products between zones and type sites. Nonetheless, the botanical analysis makes a major contribution to our interpretation of cultural adaptations by indicating the extensive role of plant remains in the cultural system, with all the variability in use and technology we associate with lithic artifacts. Such an empirical demonstration of the variety, abundance, and importance of plant remains carries far more weight than any number of assumptions that the prehistoric people used plant resources. The benefits to be gained from collecting, processing, identifying and quantifying this long-neglected portion of the record are clearly indicated. Perhaps the most significant finding, in terms of our interpretation of project area prehistory, is identification of a diverse array of edible plant remains from different environmental zones--goosefoot, serviceberry, hawthorn, Lomatium, and wild strawberry--in the Kartar Phase pithouses of 45-OK-11.

SUMMARY OF ECONOMIC STRATEGY BY PHASE

Above I have summarized systematic comparisons of the archaeological record using three time periods each approximately 2,000 years in duration. Comparison of the frequency and distribution of three site types and their contents demonstrates increasing differentiation of site types, increasing evenness in site type representation, and predictable variations in the richness and diversity of site type assemblages, together indicating a gradual shift along the continuum from foraging to collecting. The consistent differences among phases seem to reflect a robust underlying pattern in spite of sampling and analytic biases. Nonetheless, it is apparent that important differences are masked by our preliminary analysis, and further progress in interpreting the evolutionary sequence will require careful development of analytic units and means of circumventing sampling biases. We recognize that there is a considerable amount of variability within our analytic units--site types and phases--and that the data could be organized in alternative ways.

The following section describes general characteristics of each phase with additional descriptive information about individual sites, illustrating the variability to be found within our phases and site type categories.

KARTAR PHASE (7,000 - 4,000 B.P.)

Of the three phases, the Kartar Phase is closest to a foraging pattern. It has the least differentiation of site types and the most general economic base. The uneven proportions of site types, with Type 3 sites predominating, and equal but low numbers of Type 1 and 2 sites, is closest to the dichotomous site type structure Binford (1980) describes for foraging systems; they have only residential bases and locations. Contents of pithouses at 45-OK-11 indicate the winter low in resource productivity was offset to some extent by storing seasonal surpluses of foods at a central location, probably selected for its access to fresh winter food resources. To the degree that low residential mobility and central storage indicate logistical organization, the inhabitants were logistically organized by at least 5200-5100 B.P., the age of the earliest pithouses. We do not know if the pattern of semi-sedentism extends back further in time. All earlier Kartar Phase sites are Type 3 sites, but the record is scanty. The following generalizations apply with most confidence to the late Kartar Phase, from which most of the data derives.

The central residential base was lived in during winter and was the locus of storage year round. Small groups of individuals went on short foraging trips within the riverine zone, seldom staying away from the residential base long enough to leave evidence of domestic activities in other locations, although at least some camps were used over a period of time. Expeditions to environmental zones outside the riverine area probably involved longer stays, but whether they were accomplished by special task groups or movements of entire residential groups we cannot say. During foraging trips along the river, expedient tools, some of which were made from highly portable microblade cores, were used. A more diverse tool inventory was manufactured and kept at the residential base.

The Kartar period economy is more generalized than those of later periods. Faunal remains include proportionally more small herbivores and nonsalmonid fish, and fewer large herbivores and salmonid fish than later periods. The Kartar Phase faunal remains are more evenly distributed among categories, both in the whole assemblage and by site types, than in any other period. This suggests an encounter strategy (foraging) rather than a specialized search strategy (collecting). Not only are the faunal assemblages more even with respect to the grouped taxa, but representation within artiodactyl taxa and small herbivore taxa is also more even. As in the other phases, small herbivore remains are most common at Type 3 sites; however, only in the Kartar Phase do small herbivores occur in substantial proportions at Type 1 sites. As in the other phases, Type 1 sites have much more shell than other site types.

The analysis of site distributions in Chapter 8 suggests a community area about twice as large as in the Hudnut period. We interpret this as an indication that a relatively large territory was required to support the population during the crucial winter period and that population density was relatively low. A relatively large home range would be required if a major portion of the winter diet was supplied by ungulates hunted for immediate consumption. Although a smaller proportion of the Kartar Phase faunal remains than in later periods, ungulates still could have formed a greater proportion of the winter diet and been a more critical staple than in later times. This question might be approached by comparing data on seasonality and butchering among winter residences of different phases for indication of changes in hunting patterns.

Residential (Type 1) Sites

The primary example of a Kartar period Type 1 site is the early component at 45-OK-11 (Lohse 1984f). After an initial occupation represented by exterior activity areas, at least 13 houses were constructed between 5200-5100 and 4200 B.P. No more than three or four houses were occupied at one time. Exterior occupation surfaces and use of housepit depressions for other activities suggest continuous occupation. Seasonal indicators from houses span the entire year. That food remains collected year-round were deposited at the site does not necessarily mean that people lived there year round, but it does imply the settlement system had only one residential base. Not only was occupation at 45-OK-11 semi-sedentary, but it was also relatively permanent. We suspect that use of the same area as a residential base for several centuries was due to some unique aspects of the site location and is not necessarily a general characteristic of this time period. A possible house at 45-OK-2 (Zone 4) and the house at 45-OK-208 (Chatters 1984b) suggest some of the population lived in areas that did not allow the kind of aggregation and long term re-use recorded at 45-OK-11.

Field Camp (Type 2) Sites

The only examples of Kartar Type 2 sites are Zones 5 and 6 at 45-OK-288, described by Miss (1984d) as seasonally visited hunting camps. Zone 6, dated prior to 4800 B.P. has pits and a firepit. The sparse assemblage of materials contains a higher proportion of cobble tools and argillite objects than later zones. Faunal remains are dominated by deer, mountain sheep, and salmon. Zone 5, dated between 4800 and 4400 B.P., contains a discretely bounded exterior occupation surface with dates of 4641±150 and 4525±126. The occupation surface has a firepit, clusters of bone, clusters of FMR, and a stained area. Secondary butchering and meat processing are among the activities represented, but it is more than a transitory hunting camp. There is evidence that hide processing and stone tool manufacture and maintenance took place here as well. Plant remains include probable fruit tissue. The faunal assemblage is smaller, but richer than that of Zone 3, which contains an exterior occupation surface of Coyote Creek age. In Zone 5, antelope are more abundant and mountain sheep less than in Zone 6. Seasonal indicators minimally represent June through August and maximally May through November.

Although care must be taken in comparing these two assemblages with their disparate sample sizes, it is likely they represent two different uses of the same site. The Zone 5 occupation appears to be a temporary residence with a limited number of functions, thus falling within our expectations of a field camp. The Zone 6 assemblage qualifies as a Type 2 site because of the pit features, but otherwise is more similar to Kartar Phase Type 3 sites than to Zone 5. The unusually high proportion of choppers, hammerstones and cores and high proportions of argillite, an imported raw material, suggest lithic manufacturing was the primary activity. Miss (1984d) argues that the small linear flakes that occur in high proportions in both zones are not evidence of a microblade technology; however, this conclusion is questioned in Chapter 10.

One of the strongest arguments for interpreting the Kartar Phase adaptation as less logistical than those of later phases is the scarcity of Type 2 sites, indicating a scarcity of specially organized logistical task groups. We must consider whether the paucity of Type 2 sites is real and whether the distinction between Type 2 and Type 3 sites is appropriate in this phase. Type 2 sites may be more common than indicated by our analysis. There is some evidence of deflation in Kartar Type 3 sites; possibly these sites are more structured than we realize. At some sites, Kartar Phase occupations with features may not have been defied as separate components because they were sparse or mixed with later occupations. Zone 5 at 45-DO-211 is a particularly good example. A hearth dated at 5500 B.P. clearly falls into the Kartar Phase, but the assemblage as excavated was mixed with overlying Hudnut-age deposits, largely due to the difficulty of separating the older occupation surface from a later intrusive Hudnut pithouse.

Stations/Locations (Type 3 Sites)

The Kartar Type 3 assemblages have been interpreted by authors of the individual site reports as the remains of short-term camps, where meals were eaten, meat and plants were processed for transport, and tool kits were maintained. The assemblages assigned to this phase and site type range from very sparse ones that may not be primary cultural deposits to larger ones that provide considerable information on cultural activities. Radiocarbon dates are rare and most of the components were assigned on the basis of diagnostic projectile points or stratigraphic position below components dating around 4000 B.P. Economic faunal remains are dominated by deer; marmot, rabbit, turtle and shellfish also are found consistently from site to site. There are variations in the fauna: ground squirrel occurs at 45-DO-273, Zone 3; catostomid fish at 45-OK-2A, Zone 3; antelope and canid remains at 45-DO-243, Zone 4; and mountain sheep at 45-DO-242, Zone 4.

An example of one extreme, 45-OK-18, Zone 4, is a sparse assemblage lacking chronological diagnostics but assigned to the Kartar period because of stratigraphic position (Jaehnig 1984b). It has no economic faunal remains, no cobble tools, and no FMR, only a few scattered flakes and flake tools. Given the lack of large items, it is possible that these materials were vertically dislocated from the Hudnut component above. Most of the other assemblages, regardless of how small, include FMR and cobble tools. Although they may have been affected by deflation, they are apparently in situ. For example, Zone 5 at 45-DO-273 (Jaehnig 1984a) has only 57 lithics yet these include a chopper, tabular knife, projectile point, core, bifaces, and hammerstones.

One of the best preserved examples is Zone 3 at 45-DO-204 (Lohse 1984a). Activities, primarily butchering, were centered around a well-defined firepit with a date of 4590±143. Abundant debitage and specialized flakes indicate lithic manufacture, and a shaft abrader indicates other kinds of manufacturing activities. Botanical remains include possible root tissue, and various products of local hardwoods and conifers. Bitterbrush and pine seeds suggest summer occupation. In contrast, the small assemblage from the underlying Zone 4 contains no features, cobble tools, botanical remains, or economic faunal remains. It might be suspected of being made up of vertically dislocated material save for the 21 FMR found in one unit.

The largest Kartar Type 3 assemblages are from 45-DO-282 (Lohse 1984d). Zones 4 through 1 span a period from before 6000 B.P. until 4000 B.P. as indicated by projectile point styles, unverified by radiocarbon dates. The assemblages are characterized by unusually low numbers of shell, bone, and FMR, and the sediments generally lack indication of organic remains. It has been suggested that it was affected by deflation; however, the lack of FMR is certainly not attributable to that process, and the presence of numerous microblades in excellent condition argues against severe riverine deflation. The only features recorded in the field were unstructured artifact concentrations. Economic fauna include shellfish, rabbit, marmot, deer, turtle, and salmonid fish (although the total amount of economic bone is very small, especially in light of the volume excavated). A microblade industry is represented by cores and microblades from each zone. The primary activity at the 45-DO-282 location seems to have been the reduction of jasper and chalcedony into a wide range of butchering and processing tools; other activities such as cooking, plant food preparation, and butchering were minimal in comparison with other Kartar Type 3 sites. The conclusion that this was primarily a lithic manufacturing area should be tempered by comparison with Zone 25, the deflated surface closer to the river. The cultural remains on this surface, probably lag deposits representing the entire time span of Zones 4 to 1, are somewhat different. Shell is more abundant, artifact diversity is greater, and firepits were found. Lohse (1984d) suggests there was spatial separation of activities, with daily living activities taking place closest to the water, and specialized lithic manufacturing at the other side of the site.

The above discussion indicates that Kartar Type 3 sites are indeed short-term procurement camps with minor amounts of activities such as fire-building, and tool maintenance. The food procurement strategy seems to be an opportunistic and generalist one that takes advantage of a wide range of resources in the area. Salmonid remains are more common at Type 3 sites than at other Kartar Phase sites; presumably at least some were temporary fishing camps. The association of microblades with Type 3 sites (see Chapter 10) suggests the advantage of the microblade technology was its use of very portable materials (microblade cores) to efficiently provide expedient cutting tools. Although the preparation of blade cores to produce microblades is a specialized technology, it contributed to a generalized functional inventory.

Differences between the contents of Type 3 and Type 2 sites are slight. The critical, definitional, difference is the presence of a living floor or midden associated with at least one other feature at the Type 2 sites. If the presence of features in the Type 2 zones is due to a greater intensity and/or duration of use; the site type distinction is validated. If however, it is due simply to better geological conditions for preservation, the distinction is not justified. Further research could compare Kartar Phase Type 2 and 3 sites to determine whether there are patterned variations in faunal remains and artifact inventories indicating regular seasonal or other differences in activities, or whether differences are better attributed to variation in single hunting episodes, or sampling bias.

HUDNUT PHASE (4,000 - 2,000 B.P.)

The number of Type 3 sites drops substantially between the Kartar and Hudnut periods, and the three site types are more evenly represented although Type 1 sites are most abundant. For the first time there are a number of Type 2 sites, indicating specialized field camps used in an intensive manner. Population apparently increased and spread more evenly across the landscape. Only during this period are pithouses found on the Plateau (Douglas County) side of the river. However, the increase in site numbers and numbers of housepit sites should not be interpreted as entirely due to population increase; it could be due at least partially to use of two housepit sites--one for winter and one for a limited non-winter season--rather than just one during the year. Faunal assemblages are intermediate in richness between those of Kartar and Coyote Creek.

It is particularly with respect to the Hudnut Phase that the question is raised as to whether our site type criteria appropriately separate residential bases and field camps. We used houses as the defining criteria for residential bases, and placed no restriction on season. Pithouses in Hudnut Phase components include both winter residences used as year-round central bases and other houses used for a limited season and limited set of activities. The summer residences probably are more like our expectations of field camps; i.e. they were established at a location suitable for collecting and processing a dense resource to be transported to another location for storage. We suspect that winter residences still were the primary base camp and locus for storage in the system but we cannot rule out the possibility that the system was bi-sedentary, i.e., having two equal residences.

Residential (Type 1) Sites

Hudnut Phase components assigned to Site Type 1 include: 45-DO-211, Zone 4; 45-DO-242, Zone 3; 45-OK-2, Zone 3; 45-OK-2A, Zone 2; 45-OK-4, Zone 52; 45-OK-250, Zone 52; and 45-OK-258, Zone B. The number of houses in a single zone ranges from two houses at 45-OK-2 to five houses at 45-OK-4. The houses vary considerably among sites, but generally are characterized by an oval to circular shape, a central firepit area that was the scene of intense activity, trash pits, and other special function pits (Sammons-Lohse, Chapter 14). In contrast to Kartar Phase housepits, some processing of foods took place within the houses. Most houses were re-occupied several times, often resulting in extensive modification to the structure.

At 45-DO-211, four houses in the Hudnut Phase housepit component were at least partially excavated. Faunal remains in two of the houses include large numbers of salmonid bones, while in the other two the bones are predominantly deer, suggesting seasonally distinct activities. Dates from the houses indicate successive rather than simultaneous occupation, and alternation between winter and summer occupation between 3600 and 2700 B.P. (Lohse 1984b).

Another Hudnut Phase Type 1 site on the Douglas County side of the river is 45-DO-242. Zone 3 comprises two functionally distinct occupations. The earlier occupation, dated between 3900 and 3000 B.P. includes three housepits and is interpreted by Lohse (1984c) as a probable winter settlement. The later occupation, also intense, but apparently shorter in duration, Lohse (1984c) interprets as a possible summer habitation. Features include a shallow possible dwelling, a series of small cooking pits, a roasting pit that was used more than once, and a dense concentration of bone and shell.

Miss (1984c) contrasts the Hudnut Phase housepit occupations at 45-OK-4 and 45-OK-250 in detail. Zone 52 at 45-OK-250 includes 3 houses and is dated at 3800-2800 B.P. Zone 52 at 45-OK-4, immediately upriver includes 5 houses with a time span of 3300-2000 B.P. A number of factors suggest that 45-OK-250 is a winter residential base: high densities of shell; crushed salmon bones; deer taken in winter; low accumulations of debris; and high proportions of manufacturing and hide preparation tools such as drills, scrapers, and utilized flakes. In contrast, 45-OK-4 has whole salmon vertebrae and articulated ribs and spines, suggesting the fish were fresh, rather than stored; deer taken primarily in the spring; higher proportions of identifiable bone elements, suggesting more primary processing; higher debris accumulation rates; and greater complexity and re-use of features and surfaces. Large amounts of fresh food were apparently processed at 45-OK-4, whereas at 45-OK-250, food was stored and little processing occured.

Downriver from 45-OK-250 is 45-OK-258, another extensive Hudnut Phase housepit site with dense, complex cultural deposits. The Hudnut Phase component, dated between 3900 and 2300 B.P., includes three housepits, but like 45-OK-250 and 45-OK-4 probably is a remanant of a larger housepit village. Housepit 5 is a striking example of the re-use common in Hudnut Phases housepits. It was first excavated sometime before 2950 B.P. and the latest floor is dated at 2565±145 B.P. The minimum number of floors that can be distinctly separated is three, but the total number of episodes of re-use appears to be considerably higher.

Two houses were partially excavated in the Hudnut Phase housepit component at 45-OK-2, Zone 3. Both are shallow depressions (walls 20-30 cm high). Cultural debris is not as dense as at 45-OK-250, but has a similar spatial distribution; shell concentrations were located towards the water relative to the houses. The houses themselves were located further inland than the later Coyote Creek Phase houses, suggesting a simple transgressive sequence in which the locus of cultural activities continually moved towards the river as the bar built outward.

Field Camp (Type 2) Sites

Hudnut Type 2 sites generally are smaller than Type 1 sites and the isolation of features and occupation surfaces suggests multiple short-term re-use. Activities indicated by faunal remains and artifacts include shellfish processing, hunting, and fishing.

Zone 3, 45-DO-243, represents the remains of short-term camps in spring or fall (Lohse 1984c). Features include a small midden with shell, tabular knives, waste flakes, salmon vertebrae and a deer mandible, as well as a small pit containing salmon vertebrae. Zone 2 remains are similar, a concentration of shell with a few waste flakes and bone fragments, as well as a firepit that had been used extensively. And edge of a pit at least 90 cm in depth and containing mountain sheep and deer bone was encountered; it could have been part of a pithouse or other large construction.

The Zone 3, 45-DO-326, occupation began in the late Kartar Phase but lasted until around 3000 B.P. (Lohse 1984e). Multiple episodes of use of the rockshelter area left bounded surfaces of dense debris, associated with several large pits of uniform shape, size and construction. They are well over 1 m across, 50-80 cm deep, have "charcoal stains" at the bottom, and unidentifiable bone is the predominant cultural fill. Pits probably were even more common than the number of features suggests as there is considerable re-excavation and intersection of pits, obscuring their outlines and surfaces of origin. No pits were found outside the rockshelter area. The lithic assemblage includes a large number of microblades. Faunal remains include deer, mountain sheep, marmot, and ground squirrel.

Overlying the Kartar Phase housepit village at 45-OK-11 is a Hudnut Type 2 component dated between 3900 and 2800 B.P. The area was used repeatedly by small groups for exploiting a wide range of plant and animal resources during spring and summer (Lohse 1984f). Small hearths and FMR scatters are associated with light concentrations of artifacts and faunal debris. As in the Kartar Phase component, deer, mountain sheep, antelope, and a wide variety of smaller game were exploited, as well as river mussels and fish. Differences in the faunal and floral assemblages suggest a locally drier environment after 3800 B.P. that may be due to movement of the river away from the site area.

Zone 2, 45-OK-18, represents short-term use by small groups of people, probably for hunting (Jaehnig 1984b). The occupation comprises a dense lithic concentration including hammerstones and unmodified cobbles, a firepit associated with FMR and a moderate concentration of lithics and bone, and a second artifact concentration consisting of possible butchering tools near a concentration of bone and FMR. A radiocarbon date of 3363+394 was obtained. Faunal remains include marmot, turtle, and a deer-sized fragment. A chokecherry seed suggests late-June to mid-August occupation. Hammerstones form a relatively high percentage of the assemblage, but other cobble tools are absent. There are a few microblades in this zone, but no cores.

Location/Stations (Type 3 Sites)

Hudnut Phase Type 3 sites are generally small, sparse cultural deposits with isolated features and other cultural remains indicating short-term use for processing shellfish and meat in relatively small quantities.

In Zone 2, 45-DO-204, a thick, heavily stained surface dated around 2800 B.P. is associated with a high density of deer-sized bone fragments and butchering tools (Lohse 1984a). There is evidence of primary lithic manufacture, but no cobble tools other than a pestle. Plant remains include conifer material, probably fuel, bitterbrush seeds, grass, stripped plant cortex, and probable root tissue.

Zones 2 and 3 at 45-DO-211, late Hudnut Phase Type 3 sites, consist of shell concentrations and poorly-defined occupation surfaces. A Zone 2 shell concentration contained over 2,000 shells, with an associated millingstone and flake tools. The assemblages are quite large even in comparison to the assemblage from the housepit stratum (Zone 4), and they contain relatively more shell and lithics, less FMR and far less bone than the housepit occupation. Although the same faunal species are found in these two zones and in the housepit zone, the proportion of fish decreases and the proportion of deer increases in each successively younger zone. The deer remains in Zone 2 represent late winter/spring kills. Thus it appears that these occupations represent early spring sites focused on collecting shellfish with supplemental hunting (Lohse 1984b).

Zone 4, 45-DO-214, features are unstructured concentrations of rock and shell. Many of the shell concentrations are dense and have associated artifacts such as millingstones and tabular knives. Although it has been suggested that erosion and redeposition affected the steeply sloping site surface, the unstructured nature of the concentrations is similar to other sites of this type and may not be due to disturbance. Faunal remains, dominated by shell, also include ground squirrel, marmot, some fish, and small amounts of cervids. The botanical assemblage is largely fuel. Miss (1984a) interprets this occupation, which lacks a general range of domestic tools such as gravers, scrapers, millingstones, and anvils, as a short-term shellfish processing area.

Zone 3, 45-DO-285, is a Hudnut Phase Type 3 site dated around 3000-2000 B.P. (Miss 1984b). The faunal assemblage is dominated by bison bones, probably all from a single individual, and also includes marmot bones. The lithic assemblage includes large amounts of argillite and exhibits higher proportions of debitage and lower proportions of utilized flakes than in later Coyote Creek occupations at the same locale.

No features were recorded in Zone 3, 45-OK-18, but analysis of artifact distributions suggests a hearth area with associated food preparation and lithic manufacture, dated at 3800 B.P., and another lithic manufacturing area. A total of 90 microblades and two possible microblade core fragments were found. Faunal remains are limited to marmot, turtle, and salmonid fish. Plant remains are predominantly fuel, but also include chokecherry, which ripens in August. Jaehnig (1984b) suggests it was used by small groups for short periods of time as a base camp for hunting, fishing, and gathering.

COYOTE CREEK PHASE (2,000 B.P. to 1900 A.D.)

The Coyote Creek period subsistence system is the most logistical of all. The site types occur in the most even proportions. The faunal assemblages at all site types are less even than previously, with a greater proportion made up of deer and salmonid fish than in the Hudnut Phase. The rate of accumulation of lithics, bone, and FMR at Type 2 sites increases in this period.

Residential (Type 1) Sites

Coyote Creek Phase components with houses include: 45-OK-2, Zones 1 and 2; 45-OK-258, Component A; 45-OK-288, Zone 3. As in the case of the Kartar Phase, most of the houses are from a single site, 45-OK-2, and we are uncertain of the overall amount of variation. Houses include circular pit structures, some quite shallow, and surface structures like ethnographically described mat lodges. Postholes are rare, suggesting a different superstructure than Hudnut Phase houses, and there is little evidence of re-occupation (Sammons-Lohse, Chapter 14).

Eleven houses and a structure of unknown function in Zones 1 and 2, 45-OK-2, span the period from 1300 B.P. to after 1850 A.D. Most are circular pit structures, but the three latest houses are protohistoric or historic surface lodges. Trade goods in the two earliest of these houses, dating before 1830, are limited to ornaments; the remainder of the assemblages are similar to those in older pithouses, including stylistically uniform assemblages of chronologically appropriate projectile point types. Nails were used in construction of the youngest house, which dates after 1850. The more diverse assemblage of European goods from this house includes a powder flask. The profound effect of this functional introduction is shown by apparent cessation of projectile point manufacture, indicated by the fact that only "antique" points were found in this house. Dense occupation surfaces noted in several of the depressions over older housepits were not treated as house features but may be the remains of small circular mat lodges. Horse bones were found in one of these occupation areas and one of the historic houses described above.

The Coyote Creek Phase component at 45-OK-258 represents use of the area between at least 800 and 550 B.P. The single housepit, a shallow dwelling with walls less than 40 cm high, contains a deep, stratified pit, a firepit, an extensive bone concentration and a small shell concentration and has an associated radiocarbon date of 801±58. Later occupation of the site left dense middens or occupation surfaces, shell concentrations, firepits, pits, and bone concentrations containing varying proportions of deer, mountain sheep, and antelope bone. The largest bone concentration, roughly eight by ten meters, is in the depression over Hudnut Phase Housepit 3. Skeletal representation of deer and mountain sheep is fairly complete except that skull fragments, antlers, and horn cores are rare. A radicarbon date of 631±78 B.P. from one layer and horse bones from a higher layer indicate long use of this area for dumping bone. A conical stratified pit may have been a roasting oven later re-used as a trash pit, and another, oval, pit may have once been used for cooking salmon and later, after filling, re-used for cooking river mussels. The faunal assemblage is similar to that in the Hudnut Phase housepit component, although deer, elk, and fish bones are less frequent, and mountain sheep, antelope and marmot are more frequent. The floral assemblage, less diverse than that from the Hudnut Phase component, is dominated by fuel and includes only a few edible remains, primarily goosefoot seeds.

Zone 3, 45-OK-288, dated between 1500 and 800 B.P. contains a surface structure analogous to an ethnographic mat lodge, dated at 1046±69 and 1122±65 B.P. A broad range of artifacts indicates generalized domestic activities. Faunal remains include deer, antelope, sheep and a few fish bones, and the wide variety of plant remains includes sunflower seeds. Miss (1984d) interprets this occupation as a short-term transitory, summer seasonal use for hunting and game processing like that of the other occupations at the site.

Field Camp (Type 2) Sites

Coyote Creek Type 2 sites, similar to those in the Hudnut Phase, include fishing camps, hunting camps, and shellfish collecting and processing camps. Specially prepared firepits, including earth ovens, are more frequent than in the Hudnut Phase.

The sparse occupation in Zone 1, 45-DO-204 consists of an earth oven and diffuse scatter of artifacts. FMR is much more abundant than in other zones, relative to the total assemblage size.

Zones 2 and 3, 45-DO-214, are Coyote Creek Type 2 zones interpreted as fishing stations (Miss 1984a). The two zones comprise well-preserved surfaces with many features, representing a relatively short time span between 1200 and 1000 B.P. The older occupation surface has several cooking pits, a bone concentration, and an artifact cache; Zone 2 has a cooking pit, and an earth oven. The Zone 3 cache contains finished and unfinished composite harpoon parts indicating manufacture of fishing gear at the site. The wide range of botanical remains includes both edibles and materials for construction and artifact manufacture--red cedar, yellow cedar, spruce, and yew. Zone 1 at the same site represents sporadic use of the area for activities related to hunting from 1000 B.P. until protohistoric times. Features include a hearth, a firepit, and debris scatters; there are few fish bones.

Zones 1 and 2, 45-DO-242 are Coyote Creek Type 2 zones. Lohse (1984c) interprets the older zone as the product of multiple short-term activities between 900 and 550 B.P. Features include firepits, an FMR concentration and a bone concentration. Faunal remains include marmot, beaver, and dog but are dominated by deer. The area seems to have been the scene of isolated incidences of cooking meals, butchering game, and refurbishing tool kits. In the Zone 1 occupation, dating from 550 B.P. until protohistoric times, activities probably included shellfish processing and hunting. A fairly well-defined use area consisting of a firepit and shell concentration has a radiocarbon date of 237±80. Other isolated features include two small pits, a lithic concentration and another shell concentrations. The lithic concentration resulted from the manufacture of projectile points, among other tools; it includes 10 small Plateau side-notched points, bifaces, numerous utilized flakes and abundant debitage. Faunal remains from the entire zone include rabbit, mustelid, deer, mountain sheep, salmon and turtle.

Zones 1 and 2, 45-DO-326, have firepits and large amounts of FMR, but not the pits or intensely stained surfaces characteristic of Zones 3 and 4. The Zone 2 use of the site spans the period from 1500 to 800 B.P., and the Zone 1 use from at least 300 B.P. to historic times. The remains in both zones suggest sporadic use as a hunting camp, with the primary activities being butchering and cooking (Lohse 1984e). The lithics include high proportions of projectile points and retouched and resharpened flakes. Faunal remains include deer, elk, sheep/antelope, and marmot. Cuts on elk antler in Zone 1 appear to have been made with a metal axe, indicating adoption of trade goods into traditional hunting practices.

Zone 51, 45-OK-250, dated between 2500 and 1000 B.P., falls in the late Hudnut and early Coyote Creek Phases (Miss 1984c). Features include shellfish concentrations, FMR scatters, occupation surfaces and pits. Faunal remains include marmot, dog, sheep, deer, turtle, salmonid and catastomid fish. Zone 51, 45-OK-4, slightly later, falls entirely within the Coyote Creek Phase. The occupation, less intense than at 45-OK-250, left two shell concentrations and two firepits. Faunal remains include marmot, mustelid, and deer.

In Zone 2, 45-OK-287/288, thin localized scatters of cultural debris represent transient camps (Miss 1984d). Features include a constructed firepit, an occupation surface, and an FMR scatter. Faunal remains include deer, antelope, sheep, bison, deer-sized bones and two fish bones.

Stations/Locations (Type 3 Sites)

Coyote Creek Type 3 sites represent short-term, sporadic use, and differ from those in the Hudnut Phase primarily in having higher densities of FMR. Cultural materials are so sparse in some components it is difficult to be certain they are primary cultural deposits.

Zone 1, 45-DO-243, dates to around 1500 B.P. The low density cultural deposit has no features. FMR is an abundant component in an otherwise sparse assemblage. Faunal remains include marmot, dog, deer, turtle, and salmon in relatively even proportions. Tools and wear patterns suggest cutting and butchering activities; grinding and pounding tools are absent. Lohse (1984c) suggests the site was used for short-term camps at which the primary activity was the butchering and processing of meat.

Zone 2, 45-DO-273, yielded a small assemblage dated between 1500 and 1000 B.P. Faunal remains include deer and elk bone and the lithic tools and wear patterns indicate a dominance of cutting and scraping activities. FMR scatters and a possible eroded hearth that was not featured indicate cooking. The site probably was used for one or two short intervals in connection with deer and elk hunting (Jaehnig 1984a).

Zone 1 at 45-DO-285 on Buckley Bar is a unique kind of site, not only for the Coyote Creek period, but for the entire project. The assemblage, dated between 500 B.P. and 1700 A.D. has concentrations of FMR but no structured features. Salmonid bones make up 60% of all identified bone, one of the highest zonal proportions in any site. This is the only assemblage of salmonid bones in which otoliths dominate, rather than vertebrae. The otoliths have been identified as Chinook salmon. Specialized fish butchering or preparation at this site led to the disposal of fish heads but not other parts of the fish. Deer, elk, and mountain sheep bones suggest hunting also played a role in site activities. The artifact assemblage is relatively generalized, including projectile points, drills, gravers, scrapers, tabular knives, choppers, bifaces, cores, and a variety of manufacturing products. The sparse assemblage from Zone 2, dated between 500 B.P. and 2000 B.P., may not be a primary cultural deposit. Fish bones, FMR, and utilized or modified flakes are rare and features are entirely absent.

DISCUSSION

It is important to evaluate the extent to which the patterns described above could be due to factors other than the cultural organization of the prehistoric inhabitants. Other sources of patterning including sampling biases--problems related to sample representativeness and sample size--and analytic biases. The purpose of the following discussion is to merely raise these issues; to answer them would require additional data collection and analysis.

SAMPLE REPRESENTATIVENESS

Sites were selected for intensive excavation with the goal of obtaining a sample representative of the known temporal, functional, and geographic variability in the project area (see discussion of site selection in Campbell 1984c). Excavation at the sites selected has advanced our understanding of the variability in the archaeological record and the geographic and geomorphologic distribution of sites of particular ages and kinds. This information allows us to make a post hoc evaluation of whether the data collection techniques used resulted in a representative sample of temporal and functional variability. Estimating the significance of biases in a probabilistic manner would require further data collection using a stratified sampling design incorporating information on site distribution and associations.

Restriction to Riverine Zone

Clearly our findings are biased in that work was restricted to the riverine zone (Biophysiographic Zone I, Chapter 1) and our sample does not include the upland portion of the settlement/subsistence system. There is clear evidence of the use of upland areas in the form of resources such as marten, mountain sheep, wild strawberry, and roots brought to the riverine zone for storage and use, yet we cannot describe the nature of these activities. This bias of omission should not invalidate the conclusion that organization of the cultural system within the riverine zone became increasingly logistical through time. Furthermore, we believe this change in organization characterizes the entire settlement/subsistence system. The intensity of activity in the riverine zone and the use there of foods collected at all times of the year demonstrates that the riverine zone encompassed a very large portion of the settlement pattern. Also, the riverine and upland activities were part of a linked cultural system, and it is unlikely that the two parts of the system changed in opposite directions.

Reservoir Inundation

Reservoir inundation submerges sites, essentially removing them from the accessible record. It is clear the effects of inundation are not random with respect to known site variability in the project area.

Since cultural resource management in Rufus Woods Lake first began there has been concern with differential inundation related to distance upstream from the dam. Because the depth of inundation is greatest behind the dam and decreases upstream, the total area submerged, and the maximum elevation of landforms submerged increases in a downstream direction. Because the downstream portion of Rufus Woods Lake is environmentally different from the upstream end, our overall view of cultural activities in the reservoir is distorted. Using pre-reservoir aerial photographs, Salo (Appendix E) was able to obtain some measure of the degree of this bias.

Inundation also affects low landforms more than high landforms. Data from excavated sites indicate that low landforms are relatively young and are associated with young sites. The lowest river bars were formed relatively late (e.g. Buckley Bar, formed after 3,000 B.P.) and are associated with sites of younger age. Under-representation of young sites has certainly resulted from reservoir inundation.

Evidence from excavated sites indicates that some activities, represented either as whole sites or segregated areas within sites, were conducted at low elevations close to the water. For example, one of the lowest elevation sites in the project area, protected from submergence because it is so far upstream, is Zone 1 at 45-DO-285. This component contains evidence of fish processing that is unique in the project area, providing some indication of the kinds of sites that may have been lost through inundation. In particular, the mass processing of riverine resources and attendant dumping of waste products would have been associated with the waterfront. Excavations at 45-OK-250 and 45-OK-2, among others, indicate that housepits were built slightly back from the river and that refuse such as shell and bone was dumped towards the river in front of the houses. Given this spatial patterning within housepit sites, the dump areas at relatively recent housepit sites may be submerged. This possibility must be born in mind in comparing the Coyote Creek Phase components at 45-OK-2, which have relatively little shell, with earlier Hudnut Phases housepit sites in which shell is extremely abundant. The difference may be an artifact of inundation and not represent a change in the economy.

Reservoir formation also affects the data base apart from inundation. Subsequent impacts and modifications connected with the reservoir are related to distances above the pool level. The guide-taking lines defining the project boundaries cross-cut natural elevational zones parallel to the river. In the lower portion of the reservoir, the project looked almost exclusively at T2 or T3 terraces as these were in the zone to be affected by the planned pool raise. In the upper portion of the reservoir, both older and younger landforms are preserved, but the older terraces were not accessible to the project because they were outside the guide-taking lines. Although the ages of materials recovered from the upper and lower portions overlap, there are more old components from the lower canyon and more young components from the upper canyon. Because of the differences in environment between the upstream and downstream portions of the reservoir, these two partial sequences--from T3 and T2 terraces downstream, and from T1 and T0 terraces upstream--may not together form a representative sequence for the project area.

Discovery and Sampling of Cultural Deposits

The methods by which cultural deposits were selected for intensive excavation have certainly biased the results presented here. The two most significant factors are that sites were used as the sampling unit, and that the initial universe of sites for sampling was determined by surface survey. Under this sampling strategy, cultural deposits associated with buried landforms did not have an equal probability of being selected.

At a number of project sites we found the same depositional sequence: lower bar deposits with sparse, possibly redeposited cultural materials that seldom included diagnostic artifacts or features; these were overlain by upper bar or overbank deposits with well-preserved cultural materials. If the river deposits generally built out and downriver, older cultural deposits in more stable sediments are probably inland and deeply buried. If later cultural activities moved towards the shoreline, the older deposits would not be overlain by later cultural materials and thus would not be encountered either by surface exposure or by subsurface exploration of a later site.

Because sites were found primarily through surface exposures, the probable differential association of older sites with buried landforms can be assumed to have biased the original site survey results. The occurrence of eroded bank exposures in survey and the extensiveness of the testing program in which many older deposits not visible on the surface were tested offset this bias to some degree. Nonetheless, even the 78 sites tested probably did not represent equal opportunities for finding older sites, and it was from these 78 sites that the sample of sites for intensive excavation was drawn.

The probable bias against sampling older cultural deposits built into data collection methods, coupled with the greater likelihood of older sites being destroyed by natural processes because of the length of time, imply that older sites are under-represented in the project data base. This bias could be empirically evaluated by studying distributions of components of different ages across landform types, coupled with additional subsurface testing. In the absence of empirical information on the extent to which older sites are under-represented, there is no benefit in speculating about the cultural signficance of the absence of sites predating 7000 B.P. in the project area, or the sparsity of occupations dating between 7-6000 B.P.

SAMPLE COMPARABILITY

Regardless of whether the site sample is representative or not, further biases may be introduced by making comparisons among analytic units that are not comparable because of varying sample sizes, varying temporal durations, or that are comprised of different proportions of analytic sub-units.

The construction and recognition of valid comparative samples at a regional scale is a problem whenever we sample phenomena of varying size and density in the archaeological record. Prehistoric settlement patterns generally will include sites or use-areas varying in degree of structuring, frequency of re-use, and the duration of use. Thus we expect to find both high density and low density aggregates, and both rare and abundant kinds of features and portable artifacts. It is not usually possible, or desirable, to collect larger amounts from low density sites in order to increase the sample size. To infer something of the overall organization of the economic strategy from the patterned differences between sites, we must guard against defining site types that are actually a function of sampling intensity. And, if some site types generally have low densities of cultural materials, analyses should be structured so they do not simply measure differences in sample size.

There are alternative measure of comparability. Comparability among regional units could be based on excavated volume, assemblage size, number of components, or sample size of particular subassemblages, each measure being appropriate under specific circumstances. It may sometimes be reasonable to compare sites with equal excavated volumes, regardless of size of assemblage, whereas in other cases, (e.g., comparing diversity of faunal remains) size of the particular subassemblage is a factor. The aspect of comparability most difficult to control is time. It is not valid to compare assemblages of very different durations and draw conclusions about intensity or diversity.

We have made an effort to base our generalizations on comparable samples. Nonetheless, we recognize several sample size problems that undoubtedly bias our results.

The Kartar Phase assemblage is derived from an excavated volume nearly as large as that for the later Hudnut and Coyote Creek samples. One of the major reasons the sample of this phase is so large is that a great deal of effort was devoted to 45-OK-11 once early housepits were discovered there. This resulted in a disproportionate representation of Type 1 site within the total phase assemblage. The assemblage characteristics of the overall phase assemblage largely reflect activities at 45-OK-11 alone and probably are not representative of overall cultural activities at that time.

The variability among Hudnut Phase houses has been stressed. However, the sample of Hudnut Phase houses is larger than that of other phases, and is drawn from a larger number of sites; thus, variability noted in house function in this phase may be partially an effect of the larger sample size and larger number of sources.

The assignments of components to site types may be biased by differences in sample size. For example, components with one or no features were assigned to Site Type 3. Possibly some of the components so assigned are actually very small samples of a larger occupation with abundant features. This problem is not as likely to occur as it might seem at first glance, however. Many of the small assemblages assigned to Type 3 represent a relatively large excavated volume and large spatial extent, because they were excavated over the same area as an underlying housepit occupation. The excavated volume and number of units excavated can be used as measures that we actually are sampling a low density deposit, and not merely the margin of a high density deposit. The greatest potential for sample size to play a role in erroneous site type assignments is found in the oldest component at a given site; at a number of sites the lowest components were sampled in only some units because emphasis was on recovering an extensive sample of a younger component.

ANALYTIC BIASES

The meaning of our results is determined partially by the temporal and functional analytic units used. The utility of the phases/periods was discussed in the Introduction to Section III. While we recognize the drawbacks of generalizations by phase, we feel it is justified for this preliminary synthesis. There are indications of periods of abrupt change within the phases, for example, the period around 5200-5000 B.P. when housepits are first seen in the project area. Nonetheless, further chronological refinement for the project area should be done by subdividing into shorter arbitrary time periods of equal duration (e.g., 1000-year periods) rather than by attempting to use the cultural record to select temporal unit boundaries--an exercise far too subject to circularity.

The simple site type classification used here--based on the presence or absence of certain kinds and associations of features--enabled us to rapidly categorize components and organize the data to obtain some preliminary generalizations. Examination of the variability among components within each site type and the amount of overlap between the site types suggests the categories are only rough approximations of residential bases, field camps, and stations/locations. While adequate for supporting the general conclusions of increasing logistical organization, they have limited utility for further research into issues raised by this research. Problems with the theoretical meaning of the site types concern both the appropriateness of the qualitative criteria and the scale of the phenomena being classified.

Although features can provide a useful measure of the degree of intensity and repetition of activities at a given site, our feature criteria are overly simplistic and involve too many assumptions. We assumed pithouses would be associated with a single kind of site, a winter residential base and primary storage locus. We expected that field camps located to exploit seasonal dense resources would have less permanent dwellings, and that the remains of these houses would be less visible archaeologically than pithouses. In addition to being surficial and thus not as well preserved, they would have been occupied for a shorter period of time, less intensively used during an equivalent period of time because more activities would take place outdoors, and less likely to be placed in the same spot year after year. Therefore, we thought these occupations could be recognized by associations of occupation surfaces or middens and structured features. However, it appears that some pithouses were used during a limited, nonwinter, season, for the processing of large amounts of fresh resources, more like the expectations for field camps in a logistically organized system. Another problem with equation of pithouses with winter residences and less substantial structures with field camps is the shift away from pithouses to less substantial surface structures for winter dwellings late in the Coyote Creek Phase.

A complicating factor is that winter and summer residences are not necessarily completely separate in space; some localities were used for both summer and winter residences. Sites 45-OK-250 and 45-OK-4 probably are remnants of a larger site used primarily for winter residence but also supporting a smaller number of summer residences (Miss 1984c). Other analytic zones were found to include more than one kind of structure, or similar structures with different contents suggesting different seasons of use. A shift in the scale of analysis of site types from zone to house might be ideal, but not necessarily practical. Assemblage sizes would be reduced, limiting comparability, and assemblages outside houses could not readily be incorporated. If analysis cannot feasibly be done at the scale of house, intra-component variation in season of use should still be taken into account.

Site Type 2 required a bounded occupation surface or a midden, and another structured feature, in order to separate structured temporary residences at which bulk processing took place from stations/locations used for limited periods of time for more generalized activities. However, a number of the zones assigned to Site Type 2 are more like our expectations of Type 3 sites; they represent low intensity use and lack evidence of intensive harvesting of particular resources. This arises partly because the criteria have been applied to zones differing in duration and periodicity of use.

Multiple features may indicate multiple instances of low intensity use, rather than a single intense use. Also, middens are too variable in density and size and too widely associated with human economic activity to be a criteria for field camps. A more stringent definition requiring a bounded occupation surface and at least two contemporaneous features indicating mass processing and/or waste disposal would result in shifting some components from Site Type 2 to Site Type 3.

The apparent changes in the site types through time raises the question of whether site type definitions should be developed that are specific to particular time periods, i.e., whether different criteria should be developed for winter residence in each phase. I would argue that only ahistorical units are appropriate and that deriving phase-specific definitions for site types would simply have the effect of making it impossible to compare among phases, as well as requiring additional assumptions.

EVOLUTION OF LOGISTICAL ORGANIZATION

The concept of the foraging-collecting continuum proposed by Binford (1980) has been useful in summarizing and interpreting the prehistoric record of the project area. Contrasting the cultural record from three different time periods in the same area, we have found a greater degree of logistical organization in each successive period. While it is relatively easy to develop many more-or-less useful measures for Binford's concepts, it is much more difficult to explain why changes in organization occurred. The project area record provides a useful data base against which hypotheses about the evolution of logistical systems can be tested.

Binford (1980) discusses only to a limited extent the mechanisms by which logistical organization evolves through time in a particular environment. He concentrates on a static approach, using modern ethnographic data to examine the types of environmental structure that favor foraging versus collecting societies. The subsistence system is expected to be quite sensitive to changes in the structure of environmental productivity, thus changes such as we have described above could be in response to environmental change. On the other hand, Binford also discusses aspects of logistical systems that could provide internal impetus for change. In particular, he points out that storage itself creates a spatial incongruency in resources, the kind of environmental structure commonly associated with logistical organization. He does not discuss the relationship between logistical strategies and specialization on a limited suite of resources, but a fairly close correlation seems likely. If a group begins to use a particular resource more intensively, spatial and temporal incongruities in productivity will be enhanced, leading to logistical reorganization. The question is which comes first, and whether either change can happen by historical accident or must be stimulated by some kind of environmental or technological change.

Each factor separating collecting from foraging systems--residential mobility, economic specialization, and storage--may arise independently in response to different selective pressures. Just as there is a continuum between foraging and collecting systems, there will be a continuum between those systems adapting primarily to spatial incongruities and those adapting primarily to temporal incongruities. Thus storage is primarily a strategy for dealing with temporal variations in resource productivity, although once in place it changes the spatial structure of resources. Residential mobility may be controlled more by compactness of resource zones and renewal of resources than by other aspects of organization, apart from storage itself. Logistical, rather than residential mobility, is implied by storage in the sense that the food is brought back to the base camp; however, the kind of logistical organization that involves specialized field camps and independent task groups develops in response to spatial incongruities and is not necessarily related.

RESIDENTIAL MOBILITY

Residential mobility is an important dimension of difference between foraging and collecting systems. Foragers go to the resource, by moving residences, whereas collectors tend to bring the resource to the consumers, which allows use of a base throughout longer periods, whether throughout the yearly cycle or over the years. As Binford points out, storage of food further adds to the cost of moving the residence and enhances the advantage of sending specialized task groups to collect food and bring it back.

We characterize the economic strategy in the project area as logistically organized collecting around 5200-5100 B.P. (4500-4400 B.P. uncorrected) because of evidence of semi-sedentariness at that time. The development of semi-sedentary settlement from the presumed earlier adaptation of mobile foraging might be related to an increase in effective moisture. A trend toward increased effective moisture, underway before 5000 B.P., did not reach its full extent until 4000 B.P. (uncorrected dates). At what point the magnitude of change was sufficient to account for an organizational change in human economic strategy is unknown.

There is no change in the minimum level of residential mobility after 5100 B.P.; in each phase there is at least one large housepit site used as a relatively permanent year-round base (45-OK-11, Kartar Phase; 45-OK-250, Hudnut Phase; and 45-OK-2, Coyote Creek Phase). Possibly, only some groups were able to live in favored locations appropriate as both winter and summer residential bases. Other groups or families may have been more mobile as they utilized less favored locations.

Effective analysis of residential mobility requires a finer resolution than the zones with which we have been working. It is possible that what we see as an agglomeration of houses indicating year-round and permanent use of a particular location resulted when the same location was used at different seasons for shorter periods of time over the centuries. At 45-DO-211, for example, there is no evidence that any of the four houses were occupied simultaneously, and they represent a shift from winter to summer to winter and back to summer occupation over a period of 2000 years. Thus, even though we have four Hudnut period housepits at one location, they present a picture of regular residential mobility rather than the reverse.

STORAGE

Storage is another independent factor in the evolution of settlement and subsistence systems. Storage is the only strategy by which groups can take advantage of abundant resources during one season to augment meager resources during another. Thus it allows a population level higher than one limited by the productivity of the least productive season. Binford (1980) points out that the introduction of storage as a strategy for dealing with temporal incongruities in resources introduces a spatial incongruity, thus further encouraging development of logistical organization. Also, some type of temporary storage is necessary in a logistical system if the entire group is to benefit from resources collected by a specialized task force.

In terms of the significance of storage in an economic strategy, the issue is not whether storage was practiced, but how effectively it was practiced. Until a storage technology is developed that can be relied upon to preserve food for some known length of time, it will not become fixed as a major aspect of the economic strategy. Salo (personal communication) has suggested that use of fruits and berries with high amounts of sorbic and benzoic acid or other chemical preservatives was critical to effective storage of meat and fish to be used in the late winter-early spring famine period. Schalk (1984) discusses the problems of bacterial infestation and oil rancification involved in fish storage, and how these vary with type and condition of fish, environmental conditions, and treatment of the fish. The greater the extent to which these problems of storage technology are solved, the more important the role of storage in the subsistence system can be.

The first form of storage in temperate regions probably took advantage of cold winter temperatures to keep food in a frozen state to extend its "life". Trial and error over the years led to the development of reliable means to combat problems of fungus, bacterial infestations, and oil rancification through effective methods of drying, smoking, and development of storage facilities that provided protection from animals and weather. As storage became more effective and reliable, it played a bigger role in the economic strategy and was a selective pressure for logistical organization.

As Schalk and Cleveland (1983) point out, archaeologists have not empirically studied prehistoric storage on the Plateau. The antiquity of storage, and the developments which made it a more reliable technology through time, have not been traced archaeologically. Based on the presence of year-round seasonal indicators and prepared fruits and roots at 45-OK-11, our impression is that storage was practiced in the project area from at least 5000 B.P. on. Food storage probably was not a major aspect of subsistence strategy until the advent of semi-sedentariness, when use of a single residential locus made storage a realistic strategy. Once winter sedentism was practiced, there would have been selective pressure to improve the effectiveness of storage technology. We have not attempted to study the different types of storage techniques or to estimate the importance of storage through time. Food caches have not been found outside habitation sites

(Campbell 1984). Possible storage pits were noted at habitation sites but the systematic comparisons of pit locations, structure, and contents needed to define storage pits have not been made.

ECONOMIC SPECIALIZATION

In the project area the economy becomes more specialized through time, i.e., a smaller number of resources provide a greater proportion of the food. A close correlation between logistical strategies and specialization on particular resources seems likely. If specialization arises independently, it will have the effect of enhancing either spatial or temporal incongruities in the resource base, and thus contributing selective pressure towards logistical organization. Specialization implies mass production and bulk harvests, which would place restraints on mobility. In a logistical system, the problem of large volumes of resources is solved by carrying out primary processing, and thus reducing bulk and weight, at the field camp before the food is carried back to the central residence. The level of storage technology might determine whether specialization could occur or how far it would proceed. There would be little incentive to collect more than could be used for immediate consumption unless it could be stored. Relative storability of two equally productive and dense resources might determine which one grew in importance in the system. Specialization places selective pressure on storage technology as well as the reverse. Because specialization involves a decrease in the diversity of staple resources, risk of crop failure would be a greater threat, and storage would be even more important.

CONCLUSIONS

I deliberately draw conservative conclusions about the relationship of environmental change to changes in human adaptation. The mid-Holocene trend toward increased effective moisture undoubtedly influenced human adaptation, but a direct relationship to a particular cultural change cannot conclusively be established. Otherwise the development ot an increasingly complex economic organization was spurred by internal mechanisms and adaptation to short-term climatic cycles and spatial variability in resource productivity within the riverine zone and surrounding uplands. The development of storage as an overwintering strategy favored increased economic specialization and reduction of residential mobility with logistically organized task groups to collect seasonally abundant resources. Shifting of site locations is largely due to very local changes in resource availability caused by shifts in the river and the impacts of human exploitation.

The Goose Lake core records a mid-Holocene trend toward increased effective moisture that is typical of the region. Radiocarbon dates from the core indicate the trend began around 6200 B.P. and climaxed around 4750 B.P. but these dates may not be reliable. Regional data indicate the warming/drying trend slowed by 5400 B.P. and was totally reversed by 4000 B.P. (Mehringer 1985). Increased effective moisture would have raised the absolute productivity of most terrestrial environments and lowered the elevational boundaries of plant communities. The greater productivity and increased diversity of resources within a certain distance of the river would have raised the carrying capacity for people, allowing population density and total population size to increase. The total area required to support a community of a particular size through the year would have decreased.

There are a number of problems in relating this climatic shift to cultural events. We do not know when the trend would have reached a particular threshhold of change significant for human adaptation. It is quite possible that an increase in terrestrial productivity sufficient to allow development of semi-sedentism was reached by 4500 B.P. (uncorrected date for earliest pithouse at 45-OK-11). However, the rise in pine pollen from around 45% above Mazama ash to around 75% at its peak is not smooth, and better dating would be helpful. Also, the age of pithouses at 45-OK-11 is a minimum date for semi-sedentism; given the sparseness of the early record the date for semi-sedentism might well be pushed back by later discoveries.

It was initially thought that apparent population expansion and the occurrence of pithouses on the Plateau side of the river after 4000 B.P. were due to increased environmental productivity in a period of greater effective moisture; the decrease in size of the home range needed to support human habitation making more areas capable of sustaining year-round subsistence. However, the expansion may be more apparent than real, given over-representation of Hudnut Phase material in the data base. Also, the pithouses on the Douglas County side may not represent winter residence, but only intensification of activities already practiced in the Kartar Phase.

The question of whether pithouses on the Plateau side of the river dated between 3900 and 2700 B.P. represent expansion of a type of occupation (winter residences) associated with pithouses elsewhere, or the addition of pithouses to an activity already practiced on the Plateau side of the river, is not resolved. I suggest that during this time period people excavated pithouses at temporary field camps established for exploiting abundant and localized resources. The relatively high cost of pithouse construction was offset by extensive re-use of existing depressions. Similar sites are lacking in the Kartar Phase because it is not logistically organized to the same degree and temporary field camps were absent or rare. Pithouses do not occur at later field camps because more portable shelters were developed.

Leeds' study of site location determinants is based on an assumption common to many locational studies, i.e. that a given location has some unvarying characteristics that make it optimum for a particular activity. The number of cases of shifting site function in the project area suggests that the characteristics of a location that determined optimum use were either very transitory or so negligible that different functions were equally appropriate. Few sites do not have components reflecting different uses, and there is no consistent sequence. At one site, a winter residential site might follow a spring foraging camp while the sequence might be reversed at another site. Site 45-OK-18, apparently used throughout the Hudnut period as a spring foraging camp, is one of the few exceptions. Even where each site component is assigned to the same type shifts in site function are evident. All zones at 45-DO-285 were classified as Type 3 components but the Hudnut component contains bison bone while in the Coyote Creek component fish bones prevail. Some zones assigned to a single site type comprise more than one occupation of different function. Zone 4, 45-DO-242, includes two functionally distinct occupations: an apparent winter occupation of three pithouses with deer bones predominant in the faunal assemblage; and a spring occupation characterized by a shallow dwelling, with marmots, shellfish and mountain sheep.

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APPENDIX A:
POTENTIAL OUTPUTS FOR ACTIVITY CHAIN ANALYSIS

The cperation of the activity chain models presented in Chapter 1 should result in numerous physical outputs which could be represented in the archaeological record. Indeed, our ability to match model expectations with the physical cultural record manifest in the study region is wholly dependent on finding artifactual representation of these activities. Using relevant ethnographic and archaeological references, we have compiled a list of activity outputs which should have correlates in various artifact assemblages. The list is divided into several general categories identified by numeric series designators in units of 100. For example, the category "features" is the "800" series. Individual outputs within each category are assigned a unique sequence number within the series. Thus post molds are designated number 804.

It should be stressed that the output list as currently constituted is only a tentative approximation of the list potentially resulting from activity chain modeling. Nevertheless, this partial list provides an example of the approach and a basis for initial discussion.

100. *WORN OBJECTS, FORMED AND UNFORMED.*

    101. *Cutting implement (soft material)*
    102. *Cutting implement (hard material)*
    103. *Chopping implement (soft material)*
    104. *Chopping implement (hard material)*
    105. *Scraping implement (soft material)*
    106. *Scraping implement (hard material)*
    107. *Piercing implement*
    108. *Drilling implement (soft material)*
    109. *Drilling implement (hard material)*
    112. *Grinding implement (soft material)*
    113. *Grinding implement (hard material)*
    114. *Pounding implement (soft material)*
    115. *Pounding implement (hard material)*
    116. *Abrading implement*
    117. *Wedging implement (soft material)*
    118. *Wedging implement (hard material)*
    119. *Percussion flaking implement*
    120. *Pressure flaking implement*
    121. *Anvil*
    199. *Lithic debitage*

200. *POINTS*

  201. *Stone projectile points (whole)*
  202. *Stone projectile points (broken)*
  203. *Bone points*
  204. *Horn sockets*

300. *RAW MATERIALS*

  301. *Unmodified cobbles*
  302. *Unmodified nodules*
  303. *Unmodified chunks (usable)*
  304. *Unmodified chunks (flawed)*

400. *FLAKED STONE TOOL MANUFACTURING OUTPUTS, UNWORN*

  401. *Prepared core*
  402. *Primary decortication flake*
  403. *Secondary decortication flake*
  404. *Tertiary flake*
  405. *Bipolar flake*
  406. *Broken core*
  407. *Whole formed object (see 200,500)*
  408. *Large percussion (quarry) flake*
  409. *Pressure flake*
  411. *Exhausted core*
  412. *Tool blank*
  413. *Broken formed object (see 200, 500)*
  414. *Heat spalling*
  415. *Crazing*

500. *WHOLE FORMED OBJECTS, UNWORN*

  501. *Blade*
  502. *Microblade*
  503. *Drill*
  504. *Graver*
  505. *Scraper*
  506. *Spokeshave*
  507. *Tabular knife*
  508. *Hammerstone*
  509. *Maul*
  510. *Pestle*
  511. *Edge ground cobble*
  512. *Chopper*
  513. *Peripherally flaked cobble*
  514. *Milling stone*
  515. *Hopper mortar*
  518. *Adze*
  519. *Awl*
  520. *Needle*
  521. *Shuttle*
  522. *Biface*
  523. *Horn spoon*

600. *FAUNAL REMAINS, UNWORN, UNFORMED*

601. *Deer/elk bone*
602. *Antelope bone*
603. *Mammal bone (not deer, elk, or antelope)*
604. *Long bone splinters (large mammals)*
605. *Cranial bone fragments (large mammals)*
606. *Fish bone*
607. *Human bone*
608. *Mussel shell*
609. *Dentalium*
610. *Olivella*
611. *Marginella*

700. *FLORAL REMAINS*

701. *Charred wood (general)*
702. *Charred wood (not pine or juniper)*
703. *Charred root fragments*
704. *Charred fruit seeds*
705. *Charred vegetable seeds*
706. *Charred leaf/stem material*
707. *Charred moss*

800. *FEATURES*

801. *Talus depression*
802. *Large soil depression*
803. *Small soil depression (not post mold)*
804. *Post mold*
805. *Rock alignment*
806. *Large, flat rocks*
807. *Cairn*
808. *Inhumation (see also 607)*
809. *Pictograph*
810. *Burnt soil*
811. *Fire-cracked rock*

900. *MISCELLANEOUS*

901. *Pipe*
902. *Bead*
903. *Pendant*
904. *Pin*
905. *Toggle*
906. *Paint stone*

APPENDIX B:
REPORT ON FIVE TEPHRA SAMPLES FROM THE CHIEF JOSEPH DAM CULTURAL RESOURCES PROJECT

By P. Thompson Davis

This report presents analyses of tephra samples from the Chief Joseph Dam Archaeological Project accomplished during June and July, 1983. The analyses involved refractive index measurements on glass shards following the methods outlined in Virginia Steen-McIntyre's A Manual for Tephrochronology, 1977, and point counts of ferromagnesian minerals mounted with epoxy on glass slides. Opaque minerals were excluded from the counts because they are generally not diagnostic for identification of Cascade Range tephra.

SAMPLE #1, 45-DO-204 (180-190 cm)

This tephra has glass with a modal refractive index of 1.509 and an extremely narrow range of ±0.002. All my reference samples of Mazama tephra have glass refractive index values of 1.509 ±0.002. The ferromagnesian assemblage consists of hornblende (68%), hypersthene (20%), and augite (12%). Although relative percentages vary, this same assemblage characterizes our reference samples of Mazama tephra. Given the above data and the stratigraphic position, Sample #1, 45-DO-204 is undoubtedly Mazama tephra.

SAMPLE #2, 45-DO-273 (130-137 cm)

This tephra has glass with a modal refractive index of 1.509 and a reasonably narrow range of ±0.004. The ferromagnesian assemblage consists of hornblende (52%), hypersthene (24%), and augite (24%). Given the above data, Sample #2, 45-DO-273 is also undoubtedly Mazama tephra.

SAMPLE #3, 45-DO-282A (103-113 cm)

This tephra has glass with a modal refractive index of 1.498, but a range of ±0.006. The ferromagnesian assemblage consists of hornblende (60%), hypersthene (12%), and cummingtonite (28%). The low refractive index of the glass, the presence of cummingtonite, and the absence of augite suggest that this tephra is from Mount St. Helens. Our reference samples for St. Helens Yn tephra dated about 3,400 BP have similar characteristics; however, so do St. Helens S-set tephra dated about 13,000 BP. Without the stratigraphic relationship with Mazama tephra or more involved and expensive microprobe or x-ray fluorescence analyses, I cannot determine for certain which of these two St. Helens tephra sample #3, 45-DO-282A represents, but it is definitely not characteristic of Mazama.

SAMPLE #4, 45-OK-18 (33-37 cm)

This tephra has glass with a modal refractive index of 1.500, but a range of ±0.010. The ferromagnesian assemblage consists of hornblende (48%), hypersthene (40%), and cummingtonite (12%). The generally low refractive index of glass, the presence of cummingtonite, and the absence of augite suggest that this tephra is also from Mount St. Helens. Our reference samples of St. Helens P-set tephra have greater amounts of hypersthene than cummingtonite. Given the above data and the stratigraphic position, Sample #4, 45-OK-18 is most probably St. Helens P tephra, dated about 2,500 BP. However, the presence of some glass shards with high refractive indices (up to 1.510) suggests that some reworked Mazama tephra may be included in this sample.

SAMPLE #5, 45-OK-18 (67-71 cm)

This tephra has a glass modal refractive index of 1.498, and a range of ±0.004. The ferromagnesian assemblage consists of hornblende (52%), hypersthene (20%), and cummingtonite (28%). These data suggest that Sample #5, 45-OK-18 is probably St. Helens Yn, dated about 3,400 BP. Although this age does not agree with an "older than 3,700 BP" age noted in Manfred Jaehnig's letter to me dated May 7, 1983, there are no identified widespread St. Helens tephras dating between 3,400 and about 8 to 12,000 BP. St. Helens J, that dates 8 to 12,000 BP, also has more hypersthene and less cummingtonite than Sample #5.

APPENDIX C:
POLLEN ANALYSIS OF A CORE FROM REX GRANGE LAKE, DOUGLAS COUNTY, WASHINGTON

by Rinita Dalan

Pollen work at Rex Grange Lake was undertaken as part of a project aimed at establishing a standard local pollen section with which pollen sequences archaeological sites excavated by the Chief Joseph Dam Cultural Resources Project could be compared. It was hoped that lake cores from the area would provide an uninterrupted profile of air-borne pollen deposition. The discontinuous record of pollen deposition by air and water expected to occur in the river terrace deposits of the sites could then be correlated with the standard pollen section for the area. The two lakes cored initially, Seaton's Grove Lake and Rex Grange Lake, did not provide adequate sequences. Selected samples from 45-DO-214 analyzed for pollen were found to be extremely low in pollen content; this work was not pursued further. The results of the analysis of the Rex Grange Lake core are presented below.

SITE SETTING

Rex Grange Lake is in the southeast corner of the Alameda Flat Quadrangle U.S.G.S. topographic map at an elevation of approximately 770 meters. The lake lies approximately 40 km from the forest in the steppe regions of the Cascade Range rain shadow, a region dominated today by bunchgrass and sagebrush communities (Figure C-1). Forest vegetation is confined generally to mountain slopes with sufficient precipitation. The climate of the steppe regions is arid to semiarid with low precipitation. Winters are relatively cold while summers are warm-to-hot and dry (Franklin and Dyrness 1973:209). The average precipitation for Coulee City, located approximately 40 km south of Rex Grange Lake at an elevation of 731 meters, is 25.81 cm per year. The average temperature of the coldest month (January) is 24.6°F (-4.1°C), the average temperature of the warmest month (August) is 67.8°F (19.9°C), the average yearly temperature is 46.0°F (7.8°C) (Climate Summary of the United States).

COLLECTION AND SEDIMENT DESCRIPTION

The Rex Grange short core, 5 cm in diameter and 19 cm long, was recovered October 1, 1978 with a modified Livingston corer. Another core, 100 cm long, was also taken but not analyzed. This report deals with only the short core.

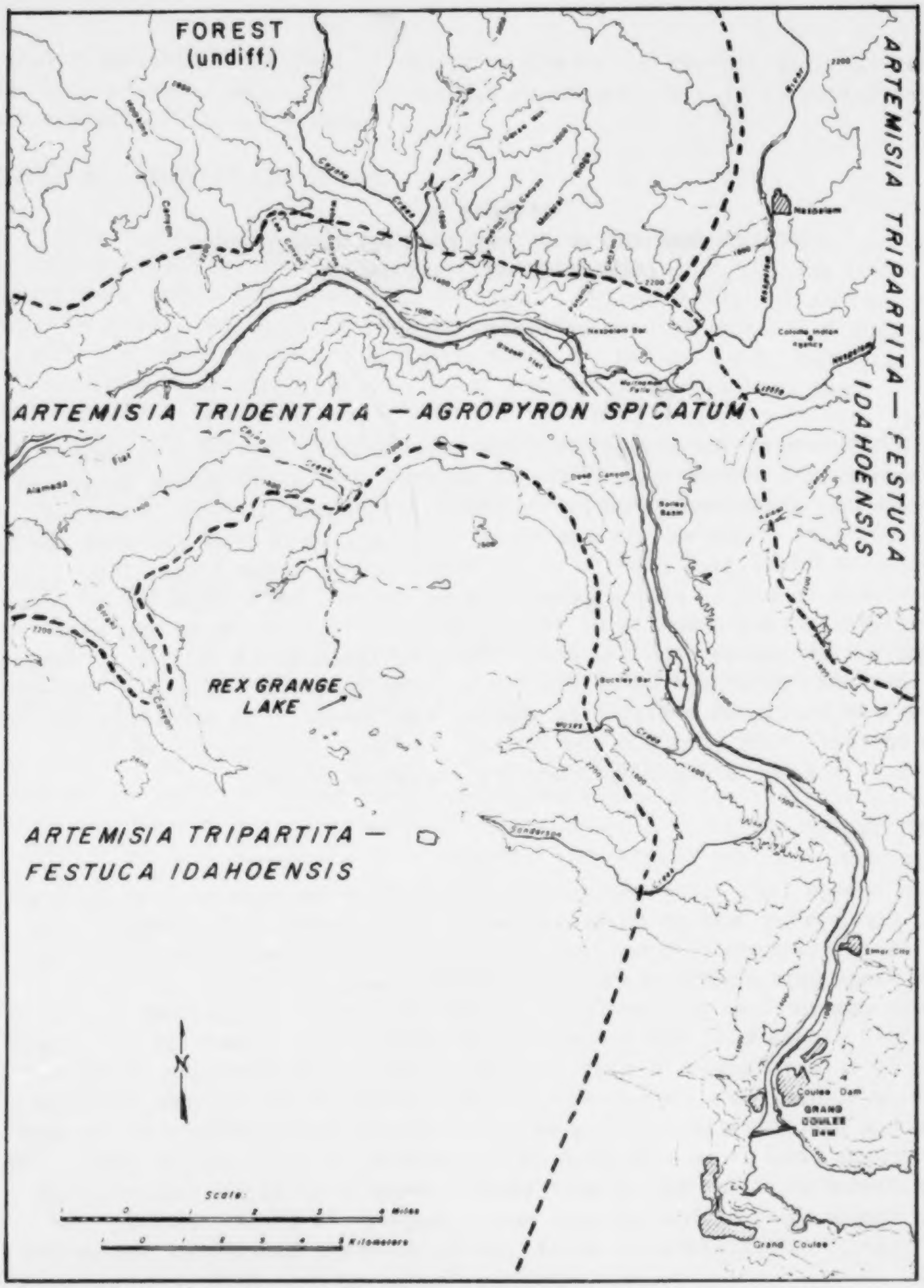
FOREST
(undiff.)
ARTEMISIA TRIDENTATA — AGROPYRON SPICATUM
ARTEMISIA TRIPARTITA — FESTUCA IDAHOENSIS
REX GRANGE LAKE
ARTEMISIA TRIPARTITA — FESTUCA IDAHOENSIS
N
Nespelem
Nespelem Bar
Buckley Bar
Elmer City
Coulee Dam
GRAND COULEE DAM
Grand Coulee
Scale
Miles
Kilometers

Figure C-1. Location of Rex Grange Lake and relation to modern vegetation zones. Zone boundaries (dashed lines) not accurately to scale because adapted from a larger scale map (Mack et al. 1979:Figure 1, in turn adapted from Daubenmire 1970:Figure 1). Also, at this larger scale the boundaries would be more complex.

The upper 7.5 centimeters of the core consists of an algal ooze which becomes consistently more solid as depth increases. Between 7.5 and 16 centimeters, the core consists of a dark brown gyttja which becomes coarser and dryer toward the bottom of the core. From 16 to 19 centimeters, the core consists of a dark brown silty clay.

Weight loss on ignition, a measure of the organic content of the sediment and the productivity of the lake, remains relatively constant (less than 10% organic) throughout the core; however, the organic content is slightly greater for the algal ooze (between 20% and 30% organic).

ANALYSIS

The Rex Grange Lake core was analyzed at the Quaternary Research Center Pollen Laboratory under the direction of Dr. Estelle Leopold and Rudy Nickmann.

In the laboratory, the core was extruded and sampled in 0.5 centimeter intervals. The samples were then stored in plastic vials. Eight samples were chosen for pollen analysis. A measured 0.5 cc volume of each sample was processed, to which a Eucalyptus spike was added. An additional 0.5 cc of sediment from each of the 8 samples was taken to determine weight loss on ignition.

Samples were treated with KOH, HF, and acetolyzed in accordance with the preparation techniques suggested by Faegri and Iversen (1975). After acetolyzation, the samples were sieved through a 7 micron nilex screen to eliminate clay size particles. To determine weight loss on ignition, samples were dehydrated and then fired in a 600°C furnace for 2.5 hours.

RESULTS

The results of the analysis are presented in the accompanying pollen diagram (Figure C-2). Generally, the diagram is dominated by Pinus (pine) throughout, with significant amounts of Gramineae (grass), Artemisia (sagebrush), other Tubuliflorae (the daisy family), and Chenopodiinae (saltbrush).

Three pollen zones were recognized in the pollen stratigraphy. Zone I is dominated by Pinus and Gramineae. Chenopodiinae and Tubuliflorae types are also present. Zone II is characterized by a decrease in Pinus and a marked increase in Chenopodiinae. Gramineae and Tubuliflorae remain in essentially the same proportions but Picea (spruce), Cupressaceae (cedar or juniper), Alnus (alder), and Artemisia make their first significant appearances. Zone III is characterized by an increase in Pinus and a decrease in Chenopodiinae. Cyperaceae (sedge) also increase significantly. Gramineae, Artemisia, and other Tubuliflorae remain in essentially the same proportions while Rosaceae (rose) increases slightly. The sediment types roughly correspond to these zonal divisions. The amount of arboreal pollen is relatively high in zone I (around 60%), decreasing somewhat in zone II (to about 37%), and increasing again in Zone III (to between 50% and 60%) at the top of the core.

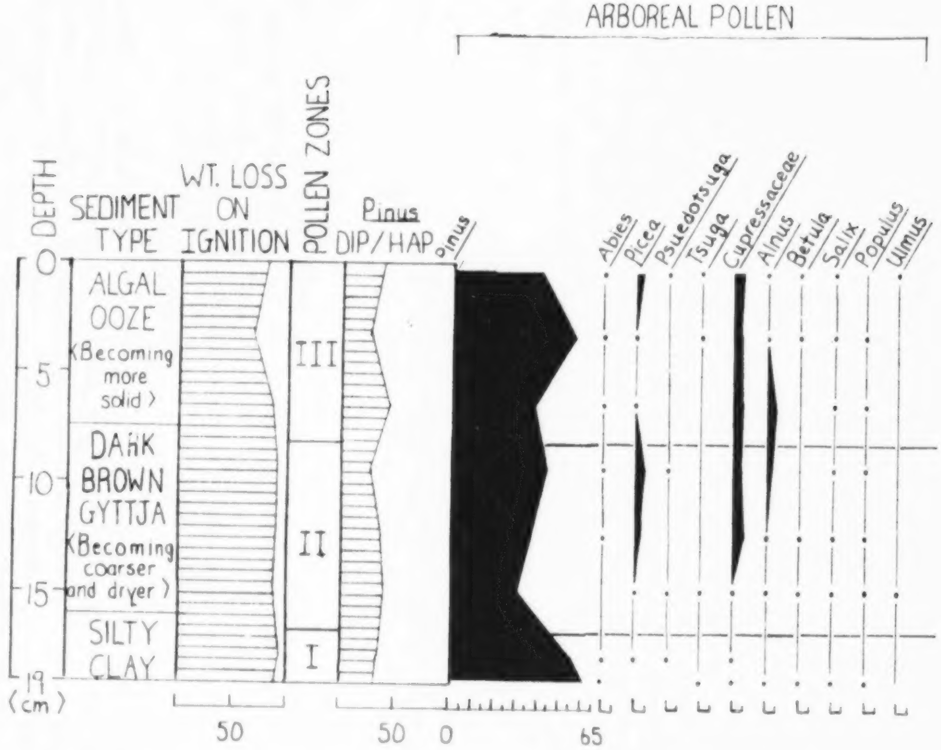

Figure C-2. Pollen diagram for Rex Grange Lake, Douglas County, Washington.

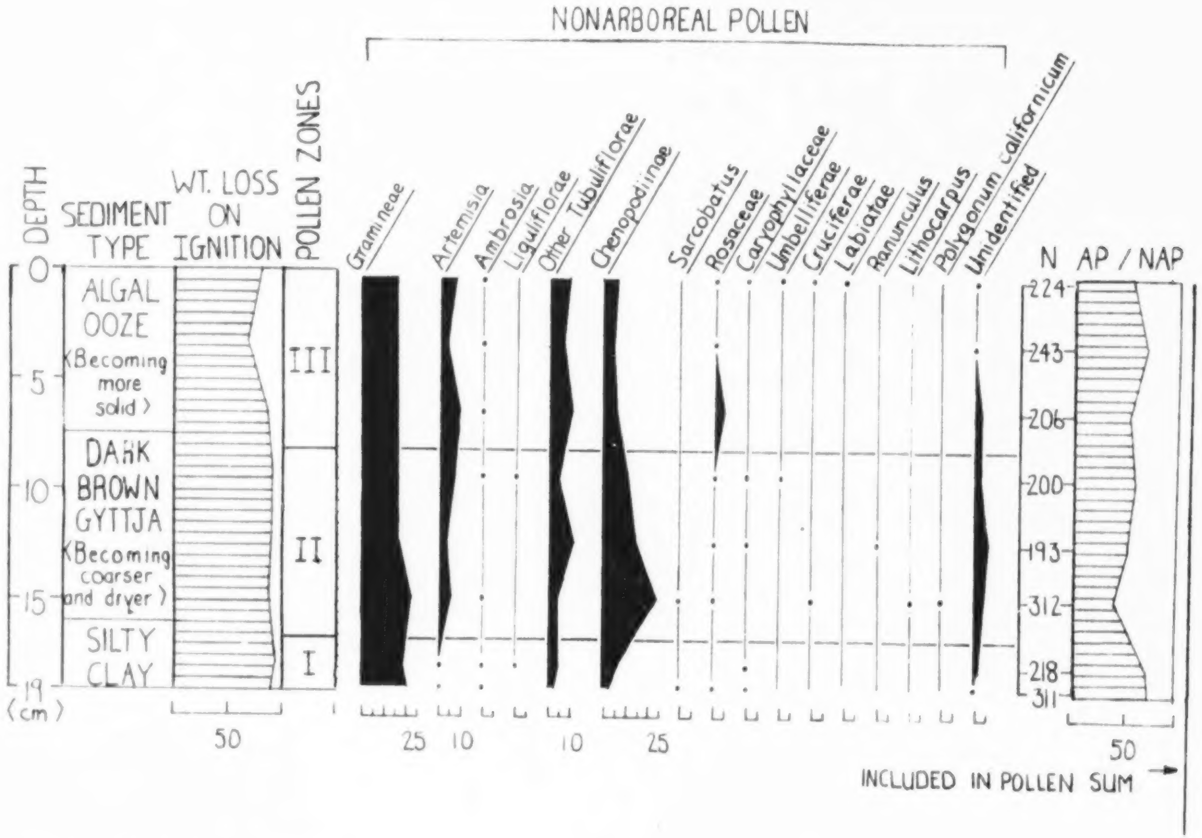

Figure C-2, cont'd.

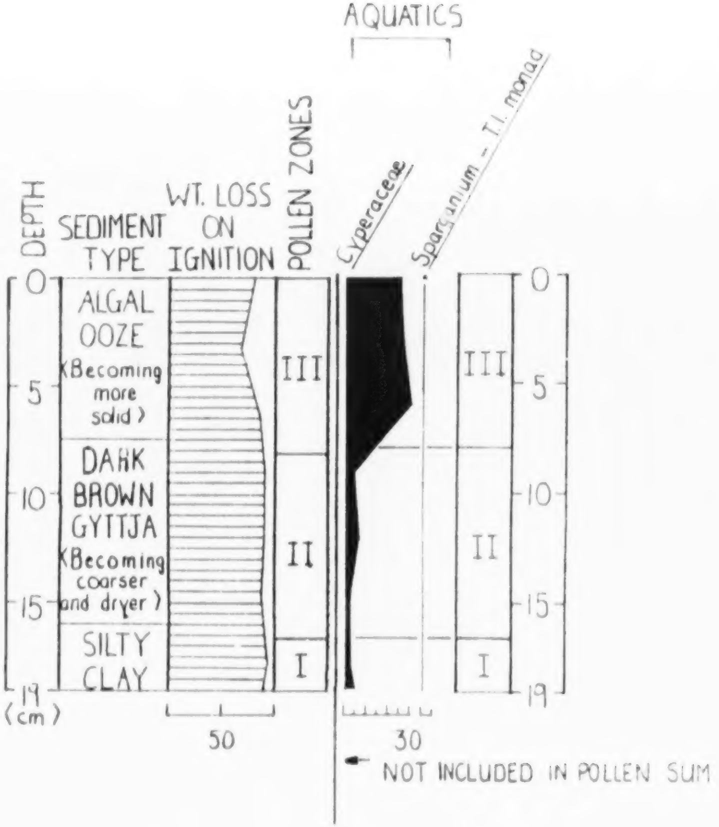

Figure C-2, cont'd.

The diploxylon to haploxylon ratio for Pinus indicates the possible presence of 4 different Pinus species. Diploxylon species are Pinus contorta and Pinus ponderosa while haploxylon species are Pinus monticola and Pinus albicaulas. The majority of Pinus is hapoloxylon. There is not any general correspondence between pollen zones and this ratio.

DISCUSSION

The small sample size and the lack of radiocarbon dates make interpretation at this point quite speculative. Nevertheless, a number of features of the pollen diagram should be noted.

First, the marked increase of Chenopodiinae in Zone II may correspond to a similar increase noted by Davis, Kolva, and Mehringer (1977) in their analysis of Wildcat Lake. They postulated that the significant increase in livestock beginning around 1870 and the subsequent destruction of the natural vegetation due to overgrazing allowed the proliferation of Chenopodiinae.

The rise in Cyperaceae (sedge) should also be noted. Although this increase could be due to a number of factors, one possible explanation is the lowering of the water level of the lake, allowing aquatics to multiply in the soft sediments surrounding the lake.

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Faegri, K. and J. Iverson
1975 **Textbook of pollen analysis.** 3rd edition, Hafner Press, New York.

Franklin, J.F., and C.T. Dyrness
1973 Natural vegetation of Oregon and Washington. **U.S. Department of Agriculture, Forest Service, General Technical Report** PNW-8.

APPENDIX D: SITE INVENTORY AND SITE CONTENT SUMMARY TABLES

Table D-1. Master inventory of habitation sites/components.

Site	Analytic Zone	Tested/ Salvaged	Chronology	Housepit	Open Camp	Reach
45-DO-102	1	T	Coyote Creek		X	9
45-DO-189	1	T	Hudnut	X		10
45-DO-190	1	T	Hudnut	X		9
45-DO-190	2	T	Hudnut	X		9
45-DO-190	3	T	Kartar		X	9
45-DO-193	-	-	Prehistoric	X		9
45-DO-198	1	T	Prehistoric		X	5
45-DO-198	2	T	Prehistoric		X	5
45-DO-201	-	-	Prehistoric		X	5
45-DO-204	1	S	Coyote Creek		X	5
45-DO-204	2	S	Hudnut		X	5
45-DO-204	3	S	Kartar		X	5
45-DO-204	4	S	Kartar		X	5
45-DO-206	-	-	Prehistoric		X	5
45-DO-207	-	-	Prehistoric		X	5
45-DO-211	1	S	Historic		X	9
45-DO-211	2	S	Hudnut		X	9
45-DO-211	3	S	Hudnut		X	9
45-DO-211	4	S	Hudnut	X		9
45-DO-211	5	S	Hudnut/ Kartar	X		9
45-DO-212	-	T	Prehistoric		X	9
45-DO-213	1	T	Prehistoric		X	9
45-DO-213	2	T	Prehistoric		X	9
45-DO-214	1	S	Coyote Creek		X	9
45-DO-214	2	S	Coyote Creek		X	9
45-DO-214	3	S	Coyote Creek		X	9
45-DO-214	4	S	Hudnut		X	9
45-DO-215	1	T	Prehistoric		X	9
45-DO-215	2	T	Prehistoric		X	9
45-DO-218	-	-	Prehistoric		X	9
45-DO-220	1	T	Prehistoric		X	9
45-DO-220	2	T	Prehistoric		X	9
45-DO-221	1	T	Prehistoric		X	9
45-DO-222	1	T	Prehistoric		X	9
45-DO-222	2	T	Coyote Creek		X	9
45-DO-233	1	T	Prehistoric		X	8
45-DO-234	1	T	Prehistoric		X	8
45-DO-234	2	T	Prehistoric		X	8
45-DO-235	-	T	Prehistoric		X	8
45-DO-236	-	T	Prehistoric		X	8
45-DO-237	-	-	Prehistoric		X	8
45-DO-238	-	-	Prehistoric		X	7
45-DO-242	1	S	Coyote Creek		X	7
45-DO-242	2	S	Coyote Creek		X	7

Table D-1, cont'd.

Site	Analytic Zone	Tested/ Salvaged	Chronology	Housepit	Open Camp	Reach
45-DO-242	3	S	Hudnut	X		7
45-DO-242	4	S	Kartar		X	7
45-DO-243	1	S	Coyote Creek		X	7
45-DO-243	2	S	Hudnut		X	7
45-DO-243	3	S	Hudnut		X	7
45-DO-243	4	S	Kartar		X	7
45-DO-246	-	-	Prehistoric		X	7
45-DO-248	1	T	Prehistoric		X	7
45-DO-249	1	T	Prehistoric		X	7
45-DO-251	-	-	Prehistoric		X	7
45-DO-254	1	T	Prehistoric		X	7
45-DO-254	2	T	Coyote Creek		X	7
45-DO-254	3	T	Prehistoric		X	7
45-DO-256	-	-	Prehistoric		X	7
45-DO-258	-	-	Prehistoric		X	6
45-DO-260	-	-	Prehistoric		X	6
45-DO-262	1	T	Prehistoric		X	6
45-DO-265	1	T	Prehistoric		X	6
45-DO-266	-	-	Prehistoric		X	6
45-DO-267	-	-	Prehistoric		X	6
45-DO-271	-	T	Prehistoric		X	5
45-DO-273	1	S	Coyote Creek/ Kartar		X	4
45-DO-273	2	S	Coyote Creek		X	4
45-DO-273	3	S	Kartar		X	4
45-DO-273	4	S	Kartar		X	4
45-DO-273	5	S	Kartar		X	4
45-DO-274	-	T	Prehistoric		-	4
45-DO-275	-	-	Prehistoric		X	4
45-DO-276	1	T	Coyote Creek		X (RS)	3
45-DO-282	1	S	Kartar		X	3
45-DO-282	2	S	Kartar		X	3
45-DO-282	3	S	Kartar		X	3
45-DO-282	4	S	Kartar		X	3
45-DO-282	5	S	Prehistoric		X	3
45-DO-284	1	T	Prehistoric	X		9
45-DO-285	1	S	Coyote Creek		X	9
45-DO-285	2	S	Coyote Creek		X	9
45-DO-285	3	S	Hudnut		X	9
45-DO-285	4	S	Hudnut		X	9
45-DO-305	-	-	Prehistoric		X	5
45-DO-306	-	-	Prehistoric		X	4
45-DO-307	-	-	Prehistoric		X	9
45-DO-308	-	-	Prehistoric		X	6
45-DO-310	-	-	Prehistoric		X	6

Table D-1, cont'd.

Site	Analytic Zone	Tested/ Salvaged	Chronology	Housepit	Open Camp	Reach
45-DO-311	-	-	Prehistoric		X	6
45-DO-312	1	T	Prehistoric		X	6
45-DO-312	2	T	Prehistoric		X	6
45-DO-325	1	T	Coyote Creek		X (RS)	9
45-DO-326	1	S	Coyote Creek		X (RS)	3
45-DO-326	2	S	Coyote Creek		X (RS)	3
45-DO-326	3	S	Hudnut		X (RS)	3
45-DO-326	4	S	Hudnut/ Kartar		X (RS)	3
45-DO-394	1	T	Hudnut		X	10
45-DO-394	2	T	Hudnut		X	10
45-DO-394	3	T	Hudnut		X	10
45-DO-394	4	T	Hudnut		X	10
45-DO-394	5	T	Hudnut		X	10
45-DO-395	-	-	Prehistoric		X	10
45-DO-439	-	T	Prehistoric		X	10
45-DO-440	-	T	Prehistoric		X	10
45-DO-12M	-	T	Prehistoric		X	10
45-DO-PSHP-1	-	-	Prehistoric	X		9
45-DO-PSHP-2	-	-	Prehistoric	X		7
45-DO-PSHP-3	-	-	Prehistoric	X		6
45-DO-PSHP-4	-	-	Prehistoric	X		6
45-DO-PSOC-1	-	-	Prehistoric		X	6
45-DO-PSOC-2	-	-	Prehistoric		X	5
45-DO-PSOC-3	-	-	Prehistoric		X	5
45-DO-PSOC-4	-	-	Prehistoric		X	5
45-DO-PSOC-5	-	-	Prehistoric		X	4
45-DO-PSOC-6	-	-	Prehistoric		X	4
45-DO-PSOC-7	-	-	Prehistoric		X	3
45-DO-PSOC-8	-	-	Prehistoric		X	3
45-DO-PSOC-9	-	-	Prehistoric		X	3
45-DO-PSOC-10	-	-	Prehistoric		X	3
45-DO-PSOC-11	-	-	Prehistoric		X	3
45-DO-PSOC-12	-	-	Prehistoric		X	2
45-DO-PSOC-13	-	-	Prehistoric		X	2
45-DO-PSOC-14	-	-	Prehistoric		X	2
45-DO-PSOC-15	-	-	Prehistoric		X	2
45-DO-PSOC-16	-	-	Prehistoric		X	1
45-DO-PSOC-17	-	-	Prehistoric		X	1
45-OK-1	1	T	Prehistoric	X		8
45-OK-2	1	S	Coyote Creek	X		8
45-OK-2	2	S	Coyote Creek	X		8
45-OK-2	3	S	Hudnut	X		8
45-OK-2A	4	S	Hudnut		X	8
45-OK-2A	1	S	Coyote Creek		X	8
45-OK-2A	2	S	Hudnut	X		8
45-OK-2A	3	S	Kartar		X	8

Table D-1, cont'd.

Site	Analytic Zone	Tested/ Salvaged	Chronology	Housepit	Open Camp	Reach
45-OK-2A	4	S	Kartar		X	8
45-OK-2A	5	S	Kartar		X	8
45-OK-3	-	-	Prehistoric	X		7
45-OK-4	1/31	S	Coyote Creek/ Hudnut		X	7
45-OK-4	1/41	S	Coyote Creek		X	7
45-OK-4	2/32	S	Hudnut	X		7
45-OK-4	2/42	S	Hudnut	X		7
45-OK-4	3/33	S	Prehistoric		X	7
45-OK-4	3/43	S	Hudnut		X	7
45-OK-5	1	T	Coyote Creek		X	7
45-OK-5	2	T	Coyote Creek	X		7
45-OK-5	3	T	Prehistoric	X		7
45-OK-6	-	-	Prehistoric	X		9
45-OK-7	1	T	Coyote Creek	X		10
45-OK-8	-	-	Prehistoric		X	8
45-OK-9	-	-	Prehistoric		X	10
45-OK-10	-	-	Prehistoric	X		7
45-OK-11	A	S	Hudnut		X	6
45-OK-11	B	S	Kartar		X	6
45-OK-11	C	S	Kartar	X		6
45-OK-11	D	S	Kartar	X		6
45-OK-11	E	S	Hudnut/ Kartar		X	6
45-OK-12	1	T	Prehistoric	X		6
45-OK-12	2	T	Prehistoric	X		6
45-OK-12	3	T	Prehistoric		X	6
45-OK-13	-	-	Prehistoric	X		5
45-OK-18	1	S	Coyote Creek/ Hudnut		X	4
45-OK-18	2	S	Hudnut		X	4
45-OK-18	3	S	Hudnut		X	4
45-OK-18	4	S	Kartar		X	4
45-OK-20	1	T	Coyote Creek	X		8
45-OK-28	1	T	Coyote Creek	X		8
45-OK-158	1	T	Coyote Creek	X		8
45-OK-160	-	-	Prehistoric	X		8
45-OK-161	-	-	Prehistoric		X	8
45-OK-162	-	-	Prehistoric	X		8
45-OK-163	-	-	Prehistoric		X	10
45-OK-164	1	T	Prehistoric		X	10
45-OK-165	1	T	Hudnut	X		9
45-OK-168	1	T	Hudnut	X		7
45-OK-168	2	T	Hudnut	X		7
45-OK-169	-	-	Prehistoric		X	1

Table D-1, cont'd.

Site	Analytic Zone	Tested/ Salvaged	Chronology	Housepit	Open Camp	Reach
45-OK-183	-	-	Prehistoric		X	5
45-OK-193	-	T	Prehistoric		X	9
45-OK-195	-	-	Prehistoric		X	9
45-OK-196	1	T	Prehistoric		X	9
45-OK-196	2	T	Coyote Creek		X	9
45-OK-196	3	T	Coyote Creek		X	9
45-OK-196	4	T	Prehistoric		X	9
45-OK-196	5	T	Hudnut		X	9
45-OK-197	1	S	Modern		X	9
45-OK-197	2	S	Coyote Creek		X	9
45-OK-197	3	S	Coyote Creek		X	9
45-OK-197	4	S	Coyote Creek		X	9
45-OK-197	5	S	Coyote Creek		X	9
45-OK-197	6	S	Coyote Creek		X	9
45-OK-197	7	S	Coyote Creek		X	9
45-OK-197	8	S	Coyote Creek		X	9
45-OK-197	9	S	Coyote Creek		X	9
45-OK-197	10	S	Coyote Creek		X	9
45-OK-197	11	S	Coyote Creek		X	9
45-OK-197	12	S	Coyote Creek		X	9
45-OK-197	13	S	Coyote Creek		X	9
45-OK-197	14	S	Coyote Creek		X	9
45-OK-197	15	S	Coyote Creek		X	9
45-OK-197	16	S	Coyote Creek		X	9
45-OK-197	17	S	Coyote Creek		X	9
45-OK-198	1	T	Historic			9
45-OK-198	2	T	Coyote Creek			9
45-OK-198	3	T	Hudnut			9
45-OK-198	4	T	Kartar			9
45-OK-199	1	T	Kartar		X	9
45-OK-204	-	-	Prehistoric		X	9
45-OK-205	1	T	Kartar		X	9
45-OK-206	-	-	Prehistoric		X	9
45-OK-207	1	T	Hudnut		X	9
45-OK-207	2	T	Kartar	X		9
45-OK-208	1	T	Hudnut		X	9
45-OK-208	2	T	Kartar	X		9
45-OK-209	-	-	Prehistoric		X	9
45-OK-210	-	-	Prehistoric		X	9
45-OK-211	-	-	Prehistoric		X	9
45-OK-217	-	-	Prehistoric		X	8
45-OK-219	1	T	Hudnut		X	9
45-OK-219	2	T	Kartar	X		9
45-OK-219	3	T	Kartar		X	9
45-OK-221	-	-	Prehistoric		X	8

Table D-1, cont'd.

Site	Analytic Zone	Tested/ Salvaged	Chronology	Housepit	Open Camp	Reach
45-OK-222	-	-	Prehistoric		X	8
45-OK-226	1	T	Coyote Creek	X		8
45-OK-226	2	T	Prehistoric		X	8
45-OK-227	-	-	Prehistoric	X		8
45-OK-228	-	-	Prehistoric		X	8
45-OK-229	1	T	Coyote Creek		X	8
45-OK-230	-	T	Prehistoric		X	8
45-OK-231	-	-	Prehistoric		X	8
45-OK-232	-	-	Prehistoric		X	8
45-OK-235	-	T	Prehistoric		X	8
45-OK-236	-	-	Prehistoric		X	8
45-OK-237	-	T	Prehistoric		X	8
45-OK-239	1	T	Coyote Creek	X		8
45-OK-239	2	T	Hudnut	X		8
45-OK-243	-	-	Prehistoric		X	7
45-OK-244	1	T	Hudnut	X		7
45-OK-244	2	T	Prehistoric		X	7
45-OK-245	1	T	Prehistoric	X		7
45-OK-246	1	T	Prehistoric	X		7
45-OK-247	1	T	Prehistoric		X	7
45-OK-247	2	T	Prehistoric		X	7
45-OK-248	1	T	Hudnut		X	7
45-OK-248	2	T	Kartar		X	7
45-OK-250	1/11	S	Coyote Creek		X	7
45-OK-250	1/12	S	Coyote Creek/ Hudnut		X	7
45-OK-250	1/21	S	Coyote Creek/ Hudnut		X	7
45-OK-250	2/13	S	Hudnut	X		7
45-OK-250	2/14	S	Hudnut		X	7
45-OK-250	2/22	S	Hudnut		X	7
45-OK-250	2/23	S	Hudnut		X	7
45-OK-250	3/15	S	Hudnut/ Kartar		X	7
45-OK-250	3/24	S	Hudnut/ Kartar		X	7
45-OK-251	-	-	Prehistoric		X	7
45-OK-252	-	-	Prehistoric	X		7
45-OK-253	1	T	Prehistoric		X	7
45-OK-253	2	T	Kartar		X	7
45-OK-254	1	T	Coyote Creek	X		7
45-OK-254	2	T	Prehistoric		X	7
45-OK-255	1	T	Prehistoric		X	7
45-OK-255	2	T	Hudnut		X	7
45-OK-256	1	T	Prehistoric		X	7

Table D-1, cont'd.

Site	Analytic Zone	Tested/ Salvaged	Chronology	Housepit	Open Camp	Reach
45-OK-256	2	T	Prehistoric		X	7
45-OK-257	1	T	Coyote Creek		X	7
45-OK-257	2	T	Hudnut	X		7
45-OK-258	1	S	Coyote Creek		X	7
45-OK-258	2	S	Coyote Creek	X		7
45-OK-258	3	S	Hudnut	X		7
45-OK-258	4	S	Hudnut	X		7
45-OK-258	5	S	Hudnut	X		7
45-OK-258	6	S	Hudnut		X	7
45-OK-259	1	T	Prehistoric		X	7
45-OK-260	-	-	Prehistoric		X	7
45-OK-261	1	T	Prehistoric		X	7
45-OK-261	2	T	Prehistoric		X	7
45-OK-264	1	T	Prehistoric		X	6
45-OK-264	2	T	Prehistoric		X	6
45-OK-265	1	T	Coyote Creek	X		6
45-OK-266	-	-	Prehistoric		X	6
45-OK-267	-	-	Prehistoric		X	6
45-OK-268	-	-	Prehistoric		X	6
45-OK-269	-	-	Prehistoric		X	6
45-OK-270	-	-	Prehistoric		X	6
45-OK-274	1	T	Coyote Creek		X	6
45-OK-274	2	T	Coyote Creek		X	6
45-OK-274	3	T	Prehistoric		X	6
45-OK-275	1	T	Prehistoric		X	6
45-OK-275	2	T	Coyote Creek/ Hudnut		X	6
45-OK-275	3	T	Hudnut		X	6
45-OK-280	1	T	Prehistoric		X	5
45-OK-280	2	T	Hudnut		X	5
45-OK-280	3	T	Prehistoric		X	5
45-OK-284	-	-	Prehistoric		X	5
45-OK-285	-	-	Prehistoric		X	5
45-OK-287	1	S	Coyote Creek		X	5
45-OK-287	2	S	Coyote Creek		X	5
45-OK-287	3	S	Coyote Creek		X	5
45-OK-287	4	S	Coyote Creek/ Hudnut		X	5
45-OK-288	1	S	Coyote Creek		X	5
45-OK-288	2	S	Coyote Creek		X	5
45-OK-288	3	S	Coyote Creek	X		5
45-OK-288	4	S	Prehistoric		X	5
45-OK-288	5	S	Kartar		X	5
45-OK-288	6	S	Kartar		X	5
45-OK-289	1	T	Prehistoric	X		5

Table D-1, cont'd.

Site	Analytic Zone	Tested/ Salvaged	Chronology	Housepit	Open Camp	Reach
45-OK-290	-	-	Prehistoric		X	5
45-OK-292	1	T	Coyote Creek		X	5
45-OK-292	2	T	Hudnut	X		5
45-OK-292	3	T	Prehistoric		X	5
45-OK-293	-	-	Prehistoric		X	5
45-OK-294	-	-	Prehistoric		X	5
45-OK-296	-	-	Prehistoric		X	5
45-OK-299	-	-	Prehistoric		X	5
45-OK-301	-	-	Prehistoric		X	5
45-OK-303	1	T	Prehistoric		X	5
45-OK-309	1	T	Prehistoric		X	3
45-OK-309	2	T	Prehistoric		X	3
45-OK-310	1	T	Prehistoric		X	3
45-OK-310	2	T	Kartar		X	3
45-OK-311	1	T	Hudnut		X	3
45-OK-312	1	T	Prehistoric		X	3
45-OK-312	2	T	Prehistoric		X	3
45-OK-313	1	T	Prehistoric		X	3
45-OK-313	2	T	Prehistoric		X	3
45-OK-313	3	T	Prehistoric		X	3
45-OK-314	1	T	Prehistoric		X	3
45-OK-315	-	-	Prehistoric		X	3
45-OK-316	-	-	Prehistoric		X	3
45-OK-317	-	-	Prehistoric		X	2
45-OK-322	-	-	Prehistoric		X	1
45-OK-323	-	-	Prehistoric		X	9
45-OK-324	-	-	Prehistoric		X	9
45-OK-327	-	-	Prehistoric		X	3
45-OK-328	-	-	Prehistoric		X	3
45-OK-329	-	-	Prehistoric		X	3
45-OK-330	-	-	Prehistoric		X	3
45-OK-331	-	-	Prehistoric		X	3
45-OK-332	-	-	Prehistoric		X	3
45-OK-333	-	-	Prehistoric		X	3
45-OK-334	-	-	Prehistoric		X	2
45-OK-338	-	T	Prehistoric		X	6
45-OK-340	1	T	Prehistoric	X		7
45-OK-347	1	T	Prehistoric		X	5
45-OK-347	2	T	Prehistoric		X	5
45-OK-452	-	-	Prehistoric	X		10
45-OK-453	-	-	Prehistoric	X		10
45-OK-454	-	-	Prehistoric	X		10
45-OK-457	-	-	Prehistoric	X		10
45-OK-458	-	-	Prehistoric	X		10
45-OK-461	-	-	Prehistoric	X		10

Table D-1, cont'd.

Site	Analytic Zone	Tested/ Salvaged	Chronology	Housepit	Open Camp	Reach
45-OK-462	-	-	Prehistoric	X		10
45-OK-463	-	-	Prehistoric	X		10
45-OK-466	-	-	Prehistoric		X	10
45-OK-471	-	-	Prehistoric		X	10
45-OK-472	-	-	Prehistoric	X		10
45-OK-473	-	-	Prehistoric		X	10
45-OK-474	-	-	Prehistoric		X	10
45-OK-PSHP-1	-	-	Prehistoric	X		9
45-OK-PSHP-2	-	-	Prehistoric	X		9
45-OK-PSHP-3	-	-	Prehistoric	X		8
45-OK-PSHP-4	-	-	Prehistoric	X		6
45-OK-PSHP-5	-	-	Prehistoric	X		6
45-OK-PSHP-6	-	-	Prehistoric	X		6
45-OK-PSHP-7	-	-	Prehistoric	X		5
45-OK-PSHP-8	-	-	Prehistoric	X		5
45-OK-PSHP-9	-	-	Prehistoric	X		5
45-OK-PSHP-10	-	-	Prehistoric	X		5
45-OK-PSHP-11	-	-	Prehistoric	X		5
45-OK-PSHP-12	-	-	Prehistoric	X		4
45-OK-PSHP-13	-	-	Prehistoric	X		3
45-OK-PSOC-1	-	-	Prehistoric		X	9
45-OK-PSOC-2	-	-	Prehistoric		X	9
45-OK-PSOC-3	-	-	Prehistoric		X	6
45-OK-PSOC-4	-	-	Prehistoric		X	5
45-OK-PSOC-5	-	-	Prehistoric		X	5
45-OK-PSOC-6	-	-	Prehistoric		X	5
45-OK-PSOC-7	-	-	Prehistoric		X	4
45-OK-PSOC-8	-	-	Prehistoric		X	3
45-OK-PSOC-9	-	-	Prehistoric		X	3
45-OK-PSOC-10	-	-	Prehistoric		X	3
45-OK-PSOC-11	-	-	Prehistoric		X	3
45-OK-PSOC-12	-	-	Prehistoric		X	3
45-OK-PSOC-13	-	-	Prehistoric		X	2
45-OK-PSOC-14	-	-	Prehistoric		X	2
45-OK-PSOC-15	-	-	Prehistoric		X	2
45-OK-PSOC-16	-	-	Prehistoric		X	2

Note: PSOC designates open camp sites detected on inundated landforms by examination of old aerial photographs. PSHP designates housepit sites detected in the same manner.

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missing

Table D-2. Salvaged habitation site characteristics.

Site	Zone	Phase	Site Type			Features								Volume	Contents					
															Bone		Shell		FMR	
			1	2	3	Housepit	Living Floor	Midden	Earth Oven	Hearth	Pit	Cache	Other		Count	Weight	Count	Weight	Count	Weight
45-00-204	1	Coyote Creek		X				1	1					63.8	524	69	0	0	245	65367
45-00-204	2	Hudnut			X			1						32.3	2318	507	0	5	188	25781
45-00-204	3	Kartar			X					1				25.5	1635	249	2	41	173	22065
45-00-204	4	Kartar			X									32.2	703	76	2	15	21	1264
45-00-211	1	Historic			X									23.7	382	52	86	101	54	6274
45-00-211	2	Hudnut			X			3						26.4	2295	442	3501	8060	359	59043
45-00-211	3	Hudnut			X			4						40.9	4066	717	3647	7251	235	43018
45-00-211	4	Hudnut	X			4		3			4			33.0	12144	2184	2248	3533	503	81966
45-00-211	5	Hudnut/Kartar	X			1					3			28.2	2231	693	311	985	86	15816
45-00-214	1	Coyote Creek		X				2		3				63.3	7433	1671	226	222	341	62158
45-00-214	2	Coyote Creek		X				1	1	1				31.3	20776	6630	114	119	1056	222583
45-00-214	3	Coyote Creek		X				4		2		1		33.3	23491	9369	215	205	237	50133
45-00-214	4	Hudnut			X			4						63.1	4304	1427	7193	21516	264	43243
45-00-242	1	Coyote Creek		X				2		1	2	1		30.5	3510	441	1726	10156	650	188126
45-00-242	2	Coyote Creek		X				4		2				33.0	5720	1749	1008	5584	469	257108
45-00-242	3	Hudnut	X			3		5		3	6			69.7	48640	18541	3188	6539	1122	274481
45-00-242	4	Kartar			X									20.3	559	196	6	0	12	5960
45-00-243	1	Coyote Creek			X									25.5	1039	346	10	13	14	1600
45-00-243	2	Hudnut		X				1	1		1			23.3	2382	1081	255	902	13	2900
45-00-243	3	Hudnut		X				2			1			17.9	2239	873	941	3355	1	5000
45-00-243	4	Kartar			X			1						18.2	834	491	116	369	1	220
45-00-273	1	Coyote Creek/ Kartar			X			1						43.1	232	284	0	0	44	26405
45-00-273	2	Coyote Creek			X			1						29.6	634	139	1	2	99	19276
45-00-273	3	Kartar			X			1						37.7	202	48	3	10	59	12070
45-00-273	4	Kartar			X									28.8	18	13	3	9	2	186
45-00-273	5	Kartar			X									19.4	1	1	2	10	0	0
45-00-282	1	Kartar			X									45.0	69	24	0	0	0	0
45-00-282	2	Kartar			X								3	40.7	52	47	2	21	6	944
45-00-282	3	Kartar			X								8	53.1	73	17	5	28	2	1090
45-00-282	4	Kartar			X					1			1	47.3	7	0	0	0	0	0
45-00-282	5	Mixed			X									0.0	32	145	0	0	90	32697

Table D-2, cont'd.

Site	Zone	Phase	Site Type			Features								Volume	Contents					
															Bone		Shell		FMR	
			1	2	3	Housepit	Living Floor	Midden	Earth Oven	Hearth	Pit	Cache	Other		Count	Weight	Count	Weight	Count	Weight
45-DO-285	1	Coyote Creek			X			1						52.9	6634	1507	2	29	872	160540
45-DO-285	2	Coyote Creek			X									26.3	2139	536	0	0	42	1346
45-DO-285	3	Hudnut			X									29.0	8465	3616	0	0	686	141721
45-DO-285	4	Hudnut			X									28.9	7050	3494	1	1	570	161364
45-DO-326	1	Coyote Creek		X				2		1				25.4	19483	4088	3	6	386	71913
45-DO-326	2	Coyote Creek			X					1	1			24.1	17394	3188	1	1	158	35904
45-DO-326	3	Hudnut		X			1			1	7			12.5	28259	3636	6	0	193	27478
45-DO-326	4	Hudnut/Kartar			X						1			30.6	22340	3307	1	1	13	3855
45-OK-2	1	Coyote Creek	X			3		13	4	1	1			152.9	67884	13387	2526	957	10344	2177446
45-OK-2	2	Coyote Creek	X			8		12	1	6	5			131.5	88808	18610	20782	26419	6928	1666698
45-OK-2	3	Hudnut	X			2		13	3	2				97.7	44340	11064	23906	7610	3104	850275
45-OK-2	4	Hudnut		X				14	2	4				84.7	35755	10759	24899	13634	1234	331441
45-OK-2A	1	Coyote Creek		X			1	5		1				21.3	5656	1200	170	1	937	114637
45-OK-2A	2	Hudnut	X			3			1		4			21.2	6700	2048	419	12	320	53456
45-OK-2A	3	Kartar			X									20.9	911	193	81	14	16	7420
45-OK-2A	4	Kartar			X									16.1	271	45	15	3	2	115
45-OK-2A	5	Kartar			X									4.8	17	3	1	0	0	0
45-OK-4	1/31	Coyote Creek/ Hudnut		X				1		1				71	17945	3601	5066	NA	1588	210083
45-OK-4	1/41	Coyote Creek		X				1		1				42.2	4908	868	1160	NA	380	124629
45-OK-4	2/32	Hudnut	X			5		11			4			78.2	148249	34505	11687	NA	3867	557810
45-OK-4	2/42	Hudnut	X			1		4			1			15	26624	6060	6758	NA	853	189258
45-OK-4	3/33	Mixed			X									21.5	5686	1505	1222	NA	56	11436
45-OK-4	3/43	Hudnut			X			2						15.7	4378	1386	2510	NA	50	10829
45-OK-11	A	Hudnut		X				6		11	1		1	306.7	58800	12304	10075	41895	4339	735628
45-OK-11	B	Kartar			X			2						45.4	14928	9971	4424	9129	608	67272
45-OK-11	C	Kartar	X			5	3	25		5	3		1	378.1	151905	66964	124568	562687	4891	793920
45-OK-11	D	Kartar	X			8		19			3			148.3	34173	13834	56022	340400	1425	216137
45-OK-11	E	Hudnut/Kartar			X			1						52.2	34953	7692	10269	47225	1084	150694

Table D-2, cont'd.

Site	Zone	Phase	Site Type			Features								Volume	Contents					
															Bone		Shell		FMR	
			1	2	3	Housepit	Living Floor	Midden	Earth Oven	Hearth	Pit	Cache	Other		Count	Weight	Count	Weight	Count	Weight
45-OK-18	1	Coyote Creek/ Hudnut			X									58.4	344	37	2	7	201	14527
45-OK-18	2	Hudnut		X						1		1		59	1949	198	13	80	597	63530
45-OK-18	3	Hudnut			X									42.1	653	41	5	41	12	1185
45-OK-18	4	Kartar			X									7.8	115	11	0	2	0	0
45-OK-250	1/11	Coyote Creek			X			1						53.8	17437	3048	1967	1069	796	231296
45-OK-250	1/21	Coyote Creek/ Hudnut			X									34.7	2311	550	322	573	157	20678
45-OK-250	1/12	Coyote Creek/ Hudnut		X				7			1			49.4	61106	13516	16417	8100	1971	211572
45-OK-250	2/22	Hudnut		X				6			1			37.9	7684	1846	7827	25103	342	127714
45-OK-250	2/13	Hudnut	X			3		2		2	1			52.3	133410	28700	34585	16744	3295	402978
45-OK-250	2/14	Hudnut			X			1						28	16170	4065	4157	1281	425	56057
45-OK-250	2/23	Hudnut			X			3						37.4	5320	1288	2184	6636	124	50714
45-OK-250	3/15	Hudnut/Kartar			X			2						66.3	14040	4217	11403	1140	167	31269
45-OK-250	3/24	Hudnut/Kartar		X				1			1			13.6	690	182	2511	575	17	2608
45-OK-258	A/1	Coyote Creek			X									81.6	19864	6269	1435	3902	1388	133836
45-OK-258	A/2	Coyote Creek	X			1		10			2			83	141546	49586	9609	22690	4237	428495
45-OK-258	B/3	Hudnut	X			1		10		3	5		1	98.4	67285	19949	21122	45782	3297	422703
45-OK-258	B/4	Hudnut	X			2		3						47.2	91849	24492	14083	30332	2114	296766
45-OK-258	B/5	Hudnut	X			1		2		1	1			49.9	72482	26022	10728	28147	1135	171082
45-OK-258	B/6	Hudnut			X									5.4	804	358	345	961	42	3618
45-OK-287	1	Coyote Creek		X				2		2				22.6	515	190	42	161	489	288929
45-OK-287	2	Coyote Creek			X					1				19.7	999	293	33	98	183	46953
45-OK-287	3	Coyote Creek			X									5.5	917	215	15	52	2	400
45-OK-287	4	Coyote Creek/ Hudnut			X									7.3	784	167	2	3	12	1455
45-OK-288	1	Coyote Creek			X									19.7	313	451	0	0	6	1098
45-OK-288	2	Coyote Creek		X				2			1			23.7	2411	897	1	0	152	36570
45-OK-288	3	Coyote Creek	X			1				2				35	15737	5285	2	7	769	121689
45-OK-288	4	Mixed		X				1			3			35.6	10374	3098	5	7	460	105482
45-OK-288	5	Kartar		X			1	2		2		1		39.8	18763	5485	18	64	693	134142
45-OK-288	6	Kartar		X				3		1	2			35.6	7147	1738	21	7	353	74895

Table D-3. Survey habitation site characteristics.

Site	Analytic Zone	Phase	Site Type 1	Site Type 2	Site Type 3	Features: Housepit	Features: Living Floor	Features: Midden	Features: Earth Oven	Features: Hearth	Features: Pit	Features: Cache	Features: Other	Volume (M^3)	Contents: Bone Count	Contents: Bone Weight (grams)	Contents: Shell Count	Contents: Shell Weight (grams)	Contents: FMR Count	Contents: FMR Weight (grams)
45-DO-10?	1	Coyote Creek			X	-	-	-	-	-	-	-	-	5.7	NA	130	NA	-	NA	7,626
45-DO-189	1	Hudnut	X			1	-	X	-	-	-	-	-	14.2	604	255	17	NA	306	13,700
45-DO-190	1	Hudnut	X			1	-	2	-	-	-	-	-	11.0	2,576	818	-	NA	1,004	67,500
45-DO-190	2	Hudnut	X			1	-	1	-	1	-	-	-	7.8	3,140	1,655	511	NA	722	73,300
45-DO-190	3	Kartar			X	-	-	-	-	1	-	-	-	4.8	276	101	48	NA	140	12,000
45-DO-198	1	--			X	-	-	-	-	-	-	-	-	8.2	NA	33	NA	-	NA	250
45-DO-198	2	--			X	-	-	-	-	-	-	-	-	8.5	NA	49	NA	-	NA	370
45-DO-212	-	--			X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45-DO-213	1	--			X	-	-	-	-	-	-	-	-	2.8	NA	28	NA	29	NA	275
45-DO-213	2	--			X	-	-	-	-	-	-	-	-	0.7	NA	4	NA	8	NA	-
45-DO-215	1	--			X	-	-	-	-	-	-	-	-	3.5	NA	33	NA	317	NA	560
45-DO-215	2	--			X	-	-	-	-	-	-	-	-	2.5	NA	4	NA	290	NA	0
45-DO-220	1				X	-	-	-	-	-	-	-	-	1.9	NA	1	NA	-	NA	900
45-DO-220	2	--			X	-	-	-	-	-	-	-	-	3.7	NA	2	NA	-	NA	0
45-D0-221	1	--			X	-	-	-	-	-	-	-	-	7.0	NA	4	NA	-	NA	-
45-DO-222	1	--			X	-	-	-	-	-	-	-	-	2.3	NA	4	NA	-	NA	0
45-DO-222	2	Coyote Creek			X	-	-	-	-	-	-	-	-	2.0	NA	0	NA	-	NA	700
45-DO-233	1	--			X	-	-	-	-	-	-	-	-	4.5	NA	4	NA	?	NA	3,955
45-DO-234	1	--			X	-	-	-	-	-	-	-	-	2.3	NA	8	NA	-	NA	60
45-DO-234	2	--			X	-	-	-	-	-	-	-	-	3.3	NA	31	NA	-	NA	777
45-DO-235	-	--			X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45-DO-236	-	--			X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45-DO-248	1	--			X	-	-	-	-	-	-	-	-	3.8	NA	6	NA	30	NA	1,270
45-DO-249	1	Mixed				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45-DO-254	1	--			X	-	-	-	-	-	-	-	-	2.0	NA	24	NA	158	NA	21
45-DO-254	2	Coyote Creek			X	-	-	-	-	-	-	-	-	2.8	NA	54	NA	3,618	NA	13,780
15-DO-254	3	--			X	-	-	-	-	-	-	-	-	2.2	NA	90	NA	449	NA	70
45-DO-262	1	--			X	-	-	-	-	-	-	-	-	4.5	NA	-	NA	-	NA	955
45-DO-265	1	--			X	-	-	-	-	-	-	-	-	5.2	NA	2	NA	-	NA	1,340
45-DO-271	-	--				-	-	-	-	-	-	-	-	-	NA	-	NA	-	NA	-
45-DO-274	-	--				-	-	-	-	-	-	-	-	-	NA	-	NA	-	NA	-
45-DO-276	1	Coyote Creek		X		-	1	-	-	-	-	-	-	5.1	NA	446	NA	10	NA	12,010
45-DO-?84	1	--	X			2	-	-	-	-	-	-	-	6.7	NA	174	NA	-	NA	22,278

Table D-3, cont'd.

						Features									Contents					
															Bone		Shell		FMR	
Site	Analytic Zone	Phase	Site Type 1	Site Type 2	Site Type 3	Housepit	Living Floor	Midden	Earth Oven	Hearth	Pit	Cache	Other	Volume (M^3)	Count	Weight (grams)	Count	Weight (grams)	Count	Weight (grams)
45-DO-312	1	--				-	-	-	-	-	-	-	-	1.8	NA	2	NA	-	NA	-
45-DO-312	2	--				-	-	-	-	-	-	-	-	3.4	NA	0	NA	-	NA	-
45-DO-325	1	Coyote Creek		X		-	1	-	-	-	-	-	-	2.3	NA	438	NA	374	NA	36,525
45-DO-394	1	Hudnut			X	-	-	1	-	-	-	-	-	3.4	517	168	12	NA	80	6,600
45-DO-394	2	Hudnut		X		-	-	1	-	1	-	-	-	4.4	358	310	278	NA	95	28,800
45-DO-394	3	Hudnut			X	-	-	-	-	1	-	-	-	2.6	63	46	21	NA	38	9,000
45-DO-394	4	Hudnut		X		-	-	1	-	1	-	-	-	5.4	63	29	438	NA	37	9,200
45-DO-394	5	Hudnut			X	-	-	-	-	-	-	-	-	2.2	61	38	3	NA	6	1,500
45-DO-12M	-	--				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45-OK-1	1	--	X			1	-	-	-	-	-	-	-	NA	NA	NA	NA	NA	NA	NA
45-OK-5	1	Coyote Creek				-	-	1	-	-	-	-	-	NA	NA	NA	NA	NA	NA	NA
45-OK-5	2	Coyote Creek	X			1	-	-	-	-	-	-	-	NA	NA	NA	NA	NA	NA	NA
45-OK-5	3	--	X			1	-	-	-	-	-	-	-	NA	NA	NA	NA	NA	NA	NA
45-OK-7	1	Coyote Creek	?			-	-	-	-	-	-	-	-	NA	NA	NA	NA	NA	NA	NA
45-OK 12	1	--	?			-	-	-	-	-	-	-	-	1.8	NA	151	NA	789	NA	7,717
45-OK-12	2	--	?			-	-	-	-	-	-	-	-	1.6	NA	94	NA	563	NA	1,198
45-OK-12	3	--			?	-	-	-	-	-	-	-	-	3.8	NA	69	NA	153	NA	53
45-OK-20	1	Coyote Creek	X			2	-	-	-	1	-	X	X	17.8	NA	841	NA	-	NA	56,067
45-OK-28	1	Coyote Creek	X			5	-	-	-	-	-	-	-	3.0	-	36	-	-	-	230
45-OK-158	1	Coyote Creek	X			2	-	-	-	-	-	-	-	4.5	NA	316	NA	-	NA	22,830
45-OK-164	1	Mixed			X	-	-	-	-	-	-	-	-	NA	NA	NA	NA	NA	NA	NA
45-OK-165	1	Hudnut	X			1	-	2	-	4	1	-	-	29.5	841		1,475	NA	296	39,100
45-OK-168	1	Hudnut	X			2?	-	-	-	1	-	-	-	2.2	NA	32	NA	332	NA	7,389
45-OK-168	2	Hudnut	X			2?	-	-	-	-	-	-	-	3.0	NA	299	NA	7,026	NA	40,856
45-OK-193	-	--			X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45-OK-196	1	Mixed			X	-	-	-	-	-	1	-	-		140		471		158	6,970
45-OK-196	2	Coyote Creek			X	-	-	-	-	-	-	-	-		90		1,157		133	6,770
45-OK-196	3	Coyote Creek			X	-	-	-	-	1	-	-	-		224		135		339	26,700
45-OK-196	4	Mixed			X	-	-	-	-	1	-	-	-		99		701		580	85,300
45-OK-196	5	Hudnut		X		-	-	1	-	3	1	-	-		661		2,606		550	204,000

Table D-3, cont'd.

Site	Analytic Zone	Phase	Site Type			Features								Volume (M³)	Contents					
															Bone		Shell		FMR	
			1	2	3	Housepit	Living Floor	Midden	Earth Oven	Hearth	Pit	Cache	Other		Count	Weight (grams)	Count	Weight (grams)	Count	Weight (grams)
45-OK-197	1	Modern		X		-	-	-	4	1	-	-	-	4.3	469	543	37	NA	709	30,700
45-OK-197	2	Coyote Creek			X	-	-	-	-	-	-	-	1	1.8	184	195	533	NA	52	3,100
45-OK-197	3	Coyote Creek			X	-	-	2	-	-	-	-	-	1.8	415	598	1,109	NA	171	21,450
45-OK-197	4	Coyote Creek		X		-	-	1	-	1	-	-	-	3.0	1,319	731	2,456	NA	289	8,010
45-OK-197	5	Coyote Creek			X	-	-	1	-	-	-	-	-	1.2	1,311	433	0	NA	12	1,750
45-OK-197	6	Coyote Creek		X		-	-	3	-	2	-	-	-	3.7	1,733	1,003	11,668	NA	383	64,970
45-OK-197	7	Coyote Creek			X	-	-	-	-	-	-	-	-	2.5	1,626	872	7,582	NA	400	79,700
45-OK-197	8	Coyote Creek		X		-	-	1	-	1	-	-	-	2.5	691	410	4,700	NA	222	27,300
45-OK-197	9	Coyote Creek		X		-	-	7	-	1	-	-	-	2.5	2,971	1,921	3,833	NA	938	127,000
45-OK-197	10	Coyote Creek		X		-	-	1	-	1	-	-	-	0.7	1,654	906	1	NA	185	26,400
45-OK-197	11	Coyote Creek		X		-	-	3	-	1	1	-	-	4.1	5,553	3,393	2	NA	416	32,500
45-OK-197	12	Coyote Creek		X		-	-	3	-	1	-	-	-	4.3	3,351	2,524	851	NA	143	20,170
45-OK-197	13	Coyote Creek			X	-	-	1	-	-	-	-	-	2.5	588	687	1	NA	26	3,570
45-OK-197	14	Coyote Creek			X	-	-	-	-	-	-	-	-	0.2	44	299	0	NA	15	3,800
45-OK-197	15	Coyote Creek		X		-	-	2	-	1	-	-	-	1.6	6,841	3,630	0	NA	67	6,890
45-OK-197	16	Coyote Creek			X	-	-	-	-	-	-	-	-	0.1	0	0	0	NA	0	0
45-OK-197	17	Coyote Creek			X	-	-	-	-	-	-	-	-	0.1	84	64	0	NA	0	0
45-OK-198	1	Historic																		
45-OK-198	2	Coyote Creek																		
45-OK-198	3	Hudnut																		
45-OK-198	4	Kartar																		
45-OK-199	1	Kartar			X	-	-	-	-	-	-	-	-	4.4	55	35.2	-	-	82	7,300
45-OK-205	1	Kartar			X	-	-	1	-	-	-	-	-	8.9	205	38	695	NA	36	8,900
45-OK-207	1	Hudnut			X	-	-	-	-	1	-	-	-	5.7	NA	NA	396	NA	305	225,000
45-OK-207	2	Kartar	X			4	-	4	-	?	-	-	-	23.9	NA	NA	9,775	NA	1,197	139,900
45-OK-208	1	Hudnut		X		-	-	1	1	-	-	-	-	3.5	1,075	345	4,584	NA	475	47,300
45-OK-209	2	Kartar	X			1	-	2	-	1	-	-	-	23.4	2,162	1,726	9,668	NA	907	94,300
45-OK-219	1	Hudnut			X	-	-	-	-	-	-	-	-	3.0	339	321	79	NA	95	6,300
45-OK-219	2	Kartar	X			1	-	4	-	1	-	-	-	11.2	1,503	516	2,112	NA	266	14,600
45-OK-219	3	Kartar			X	-	-	-	-	-	-	-	-	1.4	35	10	35	NA	6	2,800

Table D-3, cont'd.

Site	Analytic Zone	Phase	Site Type			Features								Volume (M^3)	Contents					
															Bone		Shell		FMR	
			1	2	3	Housepit	Living Floor	Midden	Earth Oven	Hearth	Pit	Cache	Other		Count	Weight (grams)	Count	Weight (grams)	Count	Weight (grams)
45-OK-226	1	Coyote Creek	X			1?	-	-	-	-	-	-	-	2.4	NA	51	NA	2	NA	12,120
45-OK-226	2	--			X	1?	-	-	-	-	-	-	-	1.0	NA	-	NA	-	NA	-
45-OK-229	1	Coyote Creek			X	-	-	-	-	-	-	-	-	8.9	NA	102	NA	-	NA	36,612
45-OK-230	-	--			X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45-OK-235	-	--			X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45-OK-237	-	--			X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45-OK-239	1	Coyote Creek	X			13?	-	-	-	-	-	-	-	9.4	NA	565	NA	-	NA	104,625
45-OK-239	2	Hudnut	X			13?	-	-	-	-	-	-	-	8.9	NA	726	NA	-	NA	16,009
45-OK-244	1	Hudnut	X			4?	-	-	-	-	-	-	-	2.4	NA	15	NA	-	NA	27,979
45-OK-244	2	--			X	4?	-	-	-	-	-	-	-	1.2	NA	8	NA	-	NA	925
45-OK-245	1	--	X			1	-	-	-	-	-	-	-	3.9	NA	68	NA	-	NA	9,020
45-OK-246	1	--	X			1	-	-	-	-	-	-	-	3.9	NA	40	NA	6	NA	64
45-OK-247	1	--			X	1?	-	-	-	-	-	-	-	1.8	NA	-	NA	-	NA	-
45-OK-247	2	--			X	1?	-	-	-	-	-	-	-	0.8	NA	-	NA	-	NA	-
45-OK-248	1	Hudnut			X	-	-	-	-	-	-	-	-	4.3	NA	43	NA	4,937	NA	8,708
45-OK-248	2	Kartar			X	-	-	-	-	-	-	-	-	4.5	NA	58	NA	223	NA	30
45-OK-253	1	--			X	-	-	-	-	-	-	-	-	1.8	NA	28	NA	90	NA	470
45-OK-253	2	Kartar			X	-	-	-	-	-	-	-	-	4.2	NA	315	NA	6,108	NA	6,356
45-OK-254	1	Coyote Creek	X			2?	-	-	-	-	-	-	-	5.2	NA	74	NA	-	NA	4,240
45-OK-254	2	--			X	2?	-	-	-	-	-	-	-	4.4	NA	72	NA	-	NA	730
45-OK-255	1	--			X	-	-	-	-	-	-	-	X	6.2	NA	47	NA	34	NA	819
45-OK-255	2	Hudnut			X	-	-	-	-	-	-	-	-	8.2	NA	303	NA	946	NA	3,435
45-OK-256	1	--			X	-	-	-	-	-	-	-	-	2.5	NA	104	NA	81	NA	3,064
45-OK-256	2	--			X	-	-	-	-	-	-	-	-	1.5	NA	358	NA	1,515	NA	3,164
45-OK-257	1	Coyote Creek			X	5?	-	-	-	-	-	-	-	5	NA	198	NA	103	NA	2,953
45-OK-257	2	Hudnut	X			5?	-	-	-	-	-	-	-	10.8	NA	1,661	NA	3,176	NA	26,588
45-OK-259	1	--			X	-	-	-	-	-	-	-	-	2.9	NA	5	NA	2	NA	585
45-OK-261	1	--			X	-	-	-	-	-	-	-	-	1.9	NA	2	NA	4	NA	1,262
45-OK-261	2	--			X	-	-	-	-	-	-	-	-	1.2	NA	4	NA	-	NA	1,937

Table D-3, cont'd.

						Features									Contents					
			Site Type												Bone		Shell		FMR	
Site	Analytic Zone	Phase	1	2	3	Housepit	Living Floor	Midden	Earth Oven	Hearth	Pit	Cache	Other	Volume (M^3)	Count	Weight (grams)	Count	Weight (grams)	Count	Weight (grams)
45-OK-264	1	--			X	-	-	-	-	-	-	-	-	1.0	NA	-	NA	-	NA	52
45-OK-264	2	--			X	-	-	-	-	-	-	-	-	5.2	NA	10	NA	68	NA	328
45-OK-265	1	Coyote Creek	X			5	-	-	-	-	-	-	-	10.7	NA	138	NA	-	NA	6,640
45-OK-274	1	Coyote Creek		X		-	-	-	-	-	-	-	-	1.3	NA	748	NA	-	NA	70,081
45-OK-274	2	Coyote Creek		X		-	-	-	-	-	-	-	-	1.5	NA	406	NA	-	NA	33,810
45-OK-274	3	--			X	-	-	-	-	-	-	-	-	0.7	NA	6	NA	-	NA	165
45-OK-275	1	--			X	-	-	-	-	-	-	-	-	2.7	NA	78	NA	-	NA	4,274
45-OK-275	2	Coyote Creek/Hudnut		X		-	-	-	-	-	-	-	-	9.1	NA	864	NA	-	NA	24,604
45-OK-275	3	Hudnut		X		-	-	-	-	-	-	-	-	7.0	NA	410	NA	-	NA	23,931
45-OK-280	1	--			X	-	-	-	-	-	-	-	-	8.3	NA	26	NA	-	NA	8,595
45-OK-280	2	Hudnut			X	-	-	-	-	-	-	-	-	10.8	NA	158	NA	-	NA	12,975
45-OK-280	3	--			X	-	-	-	-	-	-	-	-	2.4	NA	168	NA	-	NA	2,095
45-OK-289	1	--	X			1	-	-	-	-	-	-	-	3.6	NA	4	NA	-	NA	-
45-OK-292	1	Coyote Creek			X	2?	-	-	-	-	-	-	-	2.2	NA	10	NA	-	NA	1,705
45-OK-292	2	Hudnut	X			2?	-	-	-	-	-	-	-	3.8	NA	97	NA	-	NA	24,665
45-OK-292	3	--			X	2?	-	-	-	-	-	-	-	0.9	NA	16	NA	-	NA	26
45-OK-303	1	--			X	-	-	-	-	-	-	-	-	4.6	NA	6	NA	20	NA	-
45-OK-309	1	--			X	-	-	-	-	-	-	-	-	4.8	NA	4	NA	-	NA	-
45-OK-309	2	--			X	-	-	-	-	-	-	-	-	3.0	NA	20	NA	39	NA	90
45-OK-310	1	--			X	-	-	-	-	-	-	-	-	-(10)	NA	-	NA	-	NA	
45-OK-310	2	Kartar			X	-	-	-	-	1	-	-	-	2.8	NA	-	NA	-	NA	728
45-OK-311	1	Hudnut			X	-	-	-	-	1	-	-	-	9.1	NA	2	NA	-	NA	2,338
45-OK-312	1	--			X	-	-	-	-	-	-	-	-	1.0	NA	-	NA	-	NA	204
45-OK-312	2	--			X	-	-	-	-	-	-	-	-	3.8	NA	16	NA	-	NA	190
45-OK-313	1	--			X	-	-	-	-	-	-	-	-	-(0.1)	NA	-	NA	-	NA	-
45-OK-313	2	--			X	-	-	-	-	-	-	-	-	1.1	NA	8	NA	-	NA	830
45-OK-313	3	--			X	-	-	-	-	-	-	-	-	1.8	NA	1	NA	-	NA	80
45-OK-314	1	--			X	-	-	-	-	-	-	-	-	1.8	NA	-	NA	-	NA	-
45-OK-338	-	--			X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45-OK-340	1	--	X			9	-	-	-	-	-	-	-	4.4	NA	-	NA	18	NA	-
45-OK-347	1	--			X	-	-	-	-	-	-	-	-	0.0	NA	6	NA	8	NA	35
45-OK-347	2	--			X	-	-	-	-	-	-	-	-	11.5	NA	28	NA	44	NA	228

Table D-4. Site chronology.

Site[1]	Analytic Zone	Phase	Sub Phase	Interval	Calendar Ages (Years Before AD 1950)[2]	Dendrocorrection Reference
45-DO-102	1	Coyote Creek	B	6	500±63, 692±58	Damon, et al., 1974
45-DO-189	1	Hudnut	A	8/9	3190±147	Damon, et al., 1974
45-DO-190	1	Hudnut	A/B	8	2612±183	Damon, et al., 1974
45-DO-190	2	Hudnut	A	8/9	--	
45-DO-190	3	Kartar	B	10	5336±187 (shell)	Damon, et al., 1974
45-DO-204	1	Coyote Creek	B	6	655±67	Damon, et al., 1974
45-DO-204	2	Hudnut	A	8	2812±334	Damon, et al., 1974
45-DO-204	3	Kartar	C	10	4395±106	Damon, et al., 1974
45-DO-204	4	Kartar	B	11	--	
45-DO-211	1	Historic	--	--	--	
45-DO-211	2	Hudnut	A	8	--	
45-DO-211	3	Hudnut	A	8	--	
45-DO-211	4	Hudnut	A	8	2712±80, 2781±116, 3117±119	Damon, et al., 1974
45-DO-211	5	Hudnut	A	9	3505±74, 3636±100, 5497±142	Damon, et al., 1974
45-DO-214	1	Coyote Creek	B	6	--	
45-DO-214	2	Coyote Creek	A	7	1170±71	Damon, et al., 1974
45-DO-214	3	Coyote Creek	A	7	1046±60, 1112±71, 1122±64, 1151±88	Damon, et al., 1974
45-DO-214	4	Hudnut	A/B	8/9	--	
45-DO-222	2	Coyote Creek	A	7	--	
45-DO-242	1	Coyote Creek	B	5	237±80, 340±70	Not Corrected
45-DO-242	2	Coyote Creek	B	6	556±89, 701±85, 738±67, 914±86	Damon, et al., 1974
45-DO-242	3	Hudnut	A	9	3066±332, 3912±458	Damon, et al., 1974
45-DO-242	4	Kartar	C/B	10/11	--	
45-DO-243	1	Coyote Creek	A	7	1512±64	Damon, et al., 1974
45-DO-243	2	Hudnut	B/A	8	--	
45-DO-243	3	Hudnut	B/A	8	--	
45-DO-243	4	Kartar	B/C	10/11	--	
45-DO-244	1	Coyote Creek	--	--	165±50, 410±71; 520±63, 3518±97	Damon, et al., 1974 (165±50 not corrected)
45-DO-254	2	Coyote Creek	A	7	--	
45-DO-273	1	Coyote Creek/ Kartar	--	--	--	
45-DO-273	2	Coyote Creek	A	7	--	
45-DO-273	3	Kartar	C	10	--	
45-DO-273	4	Kartar	B	11	1036±163, 968±361	Damon, et al., 1974
45-DO-273	5	Kartar	B	12	--	
45-DO-276	1	Coyote Creek	B	6	638±153, 756±58	Damon, et al., 1974
45-DO-282	1	Kartar	C	10	--	
45-DO-282	2	Kartar	C	10	--	
45-DO-282	3	Kartar	C	10	--	
45-DO-282	4	Kartar	C	10	--	
45-DO-285	1	Coyote Creek	B	5	299±90, 350±80	Not Corrected
45-DO-285	2	Coyote Creek	A/B	6/7	--	
45-DO-285	3	Hudnut	B	8	1680±950	Damon, et al., 1974
45-DO-285	4	Hudnut	B	8	--	
45-DO-325	1	Coyote Creek	B	5/6	--	
45-DO-326	1	Coyote Creek	Proto	4	108±55, 283±75	Not Corrected
45-DO-326	2	Coyote Creek	A	7	843±81, 1278±78	Damon, et al., 1974

[1] From Leeds, et al., 1981; Chatters, 1984a and b; Lyman, 1976; and Osborne, et al., 1952.
[2] Uncorrected dates T1/2 = 5730 years.

Table D-4, cont'd.

Site[1]	Analytic Zone	Phase	Sub Phase	Interval	Calendar Ages (Years Before AD 1950)[2]	Dendrocorrection Reference
45-DO-326	3	Hudnut	A	9	3027±81	Damon, et al., 1974
45-DO-326	4	Hudnut/ Kartar	A C	9 10	3129±95	Damon, et al., 1974
45-DO-394	1	Hudnut	B	8	2911±148	Damon, et al., 1974
45-DO-394	2	Hudnut	A	8/9	--	
45-DO-394	3	Hudnut	A	9	--	
45-DO-394	4	Hudnut	A	9	3958±198	Damon, et al., 1974
45-DO-394	5	Hudnut	A	9	--	
45-OK-1	1	Coyote Creek	--	--	175±60, 574±80	Damon, et al., 1974 (175±60 not corrected)
45-OK-2	1	Coyote Creek	F/P/B	3/4/8	110 BP, 170 BP, 196±70, 227±80, 529±89, 556±80	Damon, et al., 1974, except dates 227 not corrected
45-OK-2	2	Coyote Creek	A	6/7	783±58, 839±68, 1112±95, 1131±168, 1268±95	Damon, et al., 1974
45-OK-2	3	Hudnut	A	9	3066±76, 3001±95, 3414±114	Damon, et al., 1974
45-OK-2	4	Hudnut	A	9	3926±158, 3977±153	Damon, et al., 1974
45-OK-2A	1	Coyote Creek	A	7	--	
45-OK-2A	2	Hudnut	A/B	8/9	--	
45-OK-2A	3	Kartar	C	10	--	
45-OK-2A	4	Kartar	B	10	--	
45-OK-2A	5	Kartar	B	11	--	
45-OK-4	1/31	Coyote Creek/ Hudnut	B/A B	4-8	670±63	Damon, et al., 1974
45-OK-4	1/41	Coyote Creek	A	7	--	
45-OK-4	2/32	Hudnut	B/A	8	2097±132, 2438±145, 2825±96, 2845±121, 3085±110, 3180±90	Damon, et al., 1974
45-OK-4	2/42	Hudnut	A/B	8/9	2360±94, 2895±94	Damon, et al., 1974
45-OK-4	3/43	Hudnut	A	9	3630±113	Damon, et al., 1974
45-OK-5	1	Coyote Creek	--	--	--	
45-OK-5	2	Coyote Creek	B	6	1054±158, 1190±158	Damon, et al., 1974
45-OK-7	1	Coyote Creek	P/F/H	2/3/4	--	
45-OK-11	A	Hudnut	A	9	2800±130, 3557±523, 3872±412	Damon, et al., 1974
45-OK-11	B	Kartar	C	10	4200±180	Damon, et al., 1974
45-OK-11	C	Kartar	B	10	4409±137, 4434±117, 4486±134, 4564±150, 4719±150, 4770±150 4808±130, 4858±145, 5047±249, 5085±168, 5171±151	Damon, et al., 1974
45-OK-11	D	Kartar	C B	10 11	4187±206, 4680±165, 4757±157, 4872±142, 5109±104, 5401±343	Damon, et al., 1974
45-OK-11	E	Hudnut/ Kartar	--	--	4770±150	
45-OK-18	1	Coyote Creek/ Hudnut	A B	7 8	--	
45-OK-18	2	Hudnut	A	9	3363±394	Damon, et al., 1974
45-OK-18	3	Hudnut	A	9	3780±175	Damon, et al., 1974
45-OK-18	4	Kartar	C	10	--	
45-OK-20	1	Coyote Creek	A	7	1553±75	Damon, et al., 1974
45-OK-28	1	Coyote Creek	P/F/H	2/3/4	--	
45-OK-158	1	Coyote Creek	B	6	783±67, 979±86	Damon, et al., 1974
45-OK-159	1	Coyote Creek	--	--	185±60, 227±60, 496±63, 601±69	Damon, et al., 1975 (dates 227±60 not corrected)
45-OK-165	1	Hudnut	B	8	2336±168	Damon, et al., 1974
45-OK-168	1	Hudnut	B	8	--	
45-OK-168	2	Hudnut	B	8	--	

[1] From Leeds, et al., 1981; Chatters, 1984a and b; Lyman, 1976; and Osborne, et al., 1952.
[2] Uncorrected dates T1/2 = 5730 years.

Table D-4, cont'd.

Site1/	Analytic Zone	Phase	Sub Phase	Interval	Calendar Ages (Years Before AD 1950)2/	Dendrocorrection Reference
45-OK-196	2	Coyote Creek	Proto	4	--	
45-OK-196	3	Coyote Creek	B	6	932±142	Damon, et al., 1974
45-OK-196	5	Hudnut	A	9	shell, 5289±171	Damon, et al., 1974
45-OK-197	1	Modern	Modern	1	--	
45-OK-197	2	Coyote Creek	M/F/P	2/3/4	170±110 BP (T1/2 = 5568)	Not Corrected
45-OK-197	3	Coyote Creek	B	5	--	
45-OK-197	4	Coyote Creek	B	6	583±139	Damon, et al., 1974
45-OK-197	5	Coyote Creek	B	6	--	
45-OK-197	6	Coyote Creek	B	6	756±147, 802±142	Damon, et al., 1974
45-OK-197	7	Coyote Creek	B	6	529±155	Damon, et al., 1974
45-OK-197	8	Coyote Creek	B	6	--	
45-OK-197	9	Coyote Creek	A	7	969±187	Damon, et al., 1974
45-OK-197	10	Coyote Creek	A	7	1125±158	Damon, et al., 1974
45-OK-197	11	Coyote Creek	A	7	1150±177, 1199±177	Damon, et al., 1974
45-OK-197	12	Coyote Creek	A	7	1093±148	Damon, et al., 1974
45-OK-197	13	Coyote Creek	A	7	1297±164, 1419±171	Damon, et al., 1974
45-OK-197	14	Coyote Creek	A	7	1412±152	Damon, et al., 1974
45-OK-197	15	Coyote Creek	A	7	1685±158	Damon, et al., 1974
45-OK-197	16	Coyote Creek	A	7	1647±152	Damon, et al., 1974
45-OK-197	17	Coyote Creek	A	7	1875±173	Damon, et al., 1974
45-OK-198	1	Coyote Creek	H/F	2/3	--	
45-OK-198	2	Coyote Creek	A	7	--	
45-OK-198	3	Hudnut	A	8/9	--	
45-OK-198	4	Kartar	C	10	--	
45-OK-199	1	Kartar	B/C	10	--	
45-OK-205	1	Kartar	B	12	--	
45-OK-207	1	Hudnut	B	8	--	
45-OK-207	2	Kartar	C	10	4483±168, 4664±192, 4677±177, 4658±181 (shell)	Damon, et al., 1974
45-OK-208	1	Hudnut	B	8	2465±200	Damon, et al., 1974
45-OK-208	2	Kartar	B	10	shell 5289±181	Damon, et al., 1974
45-OK-219	1	Hudnut	A	8/9	--	
45-OK-219	2	Kartar	B	10	5149±186, 5493±192 (shell)	Damon, et al., 1974
45-OK-219	3	Kartar	B	12	--	
45-OK-226	1	Coyote Creek	B	5	278±90	Not Corrected
45-OK-229	1	Coyote Creek	A/B	6/7	--	
45-OK-239	1	Coyote Creek	B	5/6	547±302	Damon, et al., 1974
45-OK-239	2	Hudnut	B	8	2324±162	Damon, et al., 1974
45-OK-244	1	Hudnut	A	9	--	
45-OK-248	1	Hudnut	A/B	8/9	--	
45-OK-248	2	Kartar	C	10	4422±194	Damon, et al., 1974
45-OK-250	1/11	Coyote Creek	A	7	--	
45-OK-250	1/12	Coyote Creek/ Hudnut	A B	7 8	--	
45-OK-250	1/21	Coyote Creek/ Hudnut	A B	7 8	--	
45-OK-250	2/13	Hudnut	A	9	2984±76, 3143±83, 3168±76, 3194±153, 3219±95, 3323±105, 3453±97	Damon, et al., 1974
45-OK-250	2/14	Hudnut	A	9	--	
45-OK-250	2/22	Hudnut	A	8	--	
45-OK-250	2/23	Hudnut	A	9	3349±89	Damon, et al., 1974
45-OK-250	3/15	Kartar/ Hudnut	C	10	4448±123	Damon, et al., 1974

1/From Leeds, et al., 1981; Chatters, 1984a and b; Lyman, 1976; and Osborne, et al., 1952.
2/Uncorrected dates T1/2 = 5730 years.

Table D-4, cont'd.

Site[1]	Analytic Zone	Phase	Sub Phase	Interval	Calendar Ages (Years Before AD 1950)[2]	Dendrocorrection Reference
45-OK-250	3/24	Kartar/ Hudnut	--	--	--	Damon, et al., 1974
45-OK-250	Burial	Coyote Creek	--	--	329+60	Not Corrected
45-OK-253	2	Kartar	C(?)	10(?)	--	
45-OK-254	1	Coyote Creek	B	6	--	
45-OK-255	2	Hudnut	A	9	3091+58	Damon, et al., 1974
45-OK-257	1	Coyote Creek	B	5/6	--	
45-OK-257	2	Hudnut	A	9	3859+582, 3872+512	Damon, et al., 1974
45-OK-258	A/1	Coyote Creek	Proto	4	Modern	
45-OK-258	A/2	Coyote Creek	B	6	559+57, 631+78, 802+58	Damon, et al., 1974
45-OK-258	B/3	Hudnut	B	8	2408+152, 2455+126	Damon, et al., 1974
45-OK-258	B/4	Hudnut	A	8	2324+125, 2565+145, 2851+103, 2925+103, 3311+81	Damon, et al., 1974
			B	9		
45-OK-258	B/5	Hudnut	A	8	2787+103, 2878+216, 2951+107	Damon, et al., 1974
45-OK-258	B/6	Hudnut	A	9	3571+78	Damon, et al., 1974
45-OK-265	1	Coyote Creek	B	6	710+58	Damon, et al., 1974
45-OK-274	1	Coyote Creek	B	6	876+95	Damon, et al., 1974
45-OK-274	2	Coyote Creek	A	7	--	
45-OK-275	2	Coyote Creek/ Hudnut	--	--	(529+253)	Damon, et al., 1974
45-OK-275	3	Hudnut	A	9	--	
45-OK-280	2	Hudnut	A	9	3532+179	Damon, et al., 1974
45-OK-287	1	Coyote Creek	B	6	628+50, 774+67	Damon, et al., 1974
45-OK-287	2	Coyote Creek	A	7	1064+64, 1399+112	Damon, et al., 1974
45-OK-287	3	Coyote Creek	A	7	--	
45-OK-287	4	Coyote Creek/ Hudnut	A	7	--	
45-OK-288	1	Coyote Creek	B	5	--	
45-OK-288	2	Coyote Creek	B	6	473+43, 756+67	Damon, et al., 1974
45-OK-288	3	Coyote Creek	A	7	923+77, 1046+69	Damon, et al., 1974
45-OK-288	4	Coyote Creek/ Hudnut/Kartar	--	--	1543+94	Damon, et al., 1974
45-OK-288	5	Kartar	B	10	4525+126, 4681+150	Damon, et al., 1974
45-OK-288	6	Kartar	B	11	--	
45-OK-292	1	Coyote Creek	A	7	--	
45-OK-292	2	Hudnut	A	9	2938+205	Damon, et al., 1974
45-OK-310	2	Kartar	B	11	5580+120	Damon, et al., 1974
45-OK-311	1	Hudnut	A	9	2901+363	Damon, et al., 1974

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[1] From Leeds, et al., 1981; Chatters, 1984a and b; Lyman, 1976; and Osborne, et al., 1952.
[2] Uncorrected dates T1/2 = 5730 years.

Table D-5. Traditional type inventories by site/component.

				Artifact Category[1]																	
Site	Zone	Phase	Feature Site Type	SHA	EGC	UTF	BLA	MIC	FLB	ANS	DRI	PPT	BPH	CHO	PFC	ADZ	CHL	WEG	DEB	BCR	FKR
45-00-204	1	Coyote Creek	2			76		1				3		1					600		
45-00-204	2	Hudnut	3			37		5			1	3		1					1100		
45-00-204	3	Karter	3	1		49		3			1	1		10					1000		
45-00-204	4	Karter	3			9		1				1							200		
45-00-211	1	Historic	3			14						4							600		
45-00-211	2	Hudnut	3			24						7							1300		
45-00-211	3	Hudnut	3			35						4		1	1				1500		
45-00-211	4	Hudnut	1			23						9		1	4				1100		
45-00-211	5	Hudnut	1			17						2		2	2				600		
45-00-214	1	Coyote Creek	2			116				2		34	1	1	1				3000		
45-00-214	2	Coyote Creek	2	1		202					3	39	4					3	5400		
45-00-214	3	Coyote Creek	2	8		209				6		34	18	1		1			5200		
45-00-214	4	Hudnut	3			86					1	13	1	2	3	1			1900		
45-00-242	1	Coyote Creek	2	1		26					2	22		1					900		
45-00-242	2	Coyote Creek	2			30			1		3	28		2					1500		
45-00-242	3	Hudnut	1			75			5	2	5	53		4					4100		1
45-00-242	4	Karter	3			1			1										100		
45-00-243	1	Coyote Creek	3			11						5							500		
45-00-243	2	Hudnut	2			17					1	4		1					800		
45-00-243	3	Hudnut	2			5				1		5		3					600		
45-00-243	4	Karter	3			3						3		3					200		
45-00-273	1	Coyote Creek/ Karter	3			27	1	10				6		1					400		
45-00-273	2	Coyote Creek	3	1		58	2	32				3		6	3				900		
45-00-273	3	Karter	3			117	2	53			2	8		3	4				1700		
45-00-273	4	Karter	3			21		7			2	3							200		
45-00-273	5	Karter	3			4	1	2				1		1					100		
45-00-282	1	Karter	3			104	2	32				2							700	1	
45-00-282	2	Karter	3			85		32			2	6							1000	2	
45-00-282	3	Karter	3			145		75			2	4		5					1700	6	
45-00-282	4	Karter	3			46		24			2	3							400		
45-00-282	5	Mixed	3			160		8			3	17		25					1300	4	
45-00-285	1	Coyote Creek	3			156	1				2	44		3					11100		
45-00-285	2	Coyote Creek	3			51						7							4300		
45-00-285	3	Hudnut	3			108	1				4	28		1					1300		
45-00-285	4	Hudnut	3			94					3	14		1					9500		
45-00-326	1	Coyote Creek	2			34		18	2		1	28			1				1900		
45-00-326	2	Coyote Creek	3			23		26	1		1	22		1					1700	1	
45-00-326	3	Hudnut	2			27		75	1		1	14	1	2					1900	2	
45-00-326	4	Hudnut/Karter	3			45	1	50	1		4	7	1	2					1200	1	
45-OK-2	1	Coyote Creek	1			367			4	6	4	145	8	17				1	22400		
45-OK-2	2	Coyote Creek	1		1	289			13	13	4	99	8	6				1	17200		
45-OK-2	3	Hudnut	1			119			12	4	4	45	5	9				2	9200		
45-OK-2	4	Hudnut	2			45			12	6		13	5	3					2700		
45-OK-2A	1	Coyote Creek	2			24					1	17		1					1500		
45-OK-2A	2	Hudnut	1			13						2		2					700		
45-OK-2A	3	Karter	3			3						1		1					200		
45-OK-2A	4	Karter	3																100		
45-OK-4	51	Coyote Creek	2			53			1		5	53	1	6					5300		
45-OK-4	52	Hudnut	1			74			4	3	4	79	6	7		2			11700		
45-OK-4	53	Hudnut/Karter	3			9						10		3					1000		
45-OK-11	A	Hudnut	2	2	1	198	1		3	1	4	127	5	20				2	23200		
45-OK-11	B	Karter	1	1	3	183	4		12	30	5	141	19	227	8		7	22	24100		7
45-OK-18	1	Coyote Creek/ Hudnut	3			59		8			1	18	1						1700		
45-OK-18	2	Hudnut	2			116	1	64			2	28							3200		
45-OK-18	3	Hudnut	3			25	1	27				10							800		
45-OK-18	4	Karter	3			1		4											100		
45-OK-250	51	Coyote Creek/ Hudnut	2		1	115	1		1		3	53	5	6					6200		
45-OK-250	52	Hudnut	1			194			20	3	12	69	12	10				3	10000		
45-OK-250	53	Hudnut/Karter	2			114					1	6	1						600		
45-OK-258	A	Coyote Creek	1		2	256	4	58			12	155		13					17500		
45-OK-258	B	Hudnut	1		3	222	1	39			10	134		18	5				18100		
45-OK-287/8	1	Coyote Creek	3			2								1					100		
45-OK-287/8	2	Coyote Creek	2			18						6		1	2				400		
45-OK-287/8	3	Coyote Creek	1			58	1		5			20		4	2				1800		
45-OK-287/8	4	Coyote Creek/ Hudnut/Karter	2		1	53	4			1		14		13	1				1500		
45-OK-287/8	5	Coyote Creek/ Hudnut/Karter	2			61	2		12	1		11		8					2900		
45-OK-287/8	6	Karter	2			29			2			4		54	4			1	1800		
		Totals		15	12	5018	31	654	113	79	118	1751	102	515	41	4	7	35			

Table D-5, cont'd.

				Artifact Category[1]																		
Site	Zone	Phase	Feature Site Type	HAM	PES	HOP	MIL	ANV	BUR	BSP	GRA	SPO	URT	SCR	TKN	NET	PIP	SHO	COO	BOO	STO	Total
45-00-204	1	Coyote Creek	2	3																		
45-00-204	2	Hudnut	3										5		6							645
45-00-204	3	Karter	3	2							1		15	2	6							1171
45-00-204	4	Karter	3								2		13	1	6							1089
45-00-211	1	Historic	3																			211
45-00-211	2	Hudnut	3	2				1					3	1	4							626
45-00-211	3	Hudnut	3				2						9	1	9							1353
45-00-211	4	Hudnut	1				1						7		6						1	1555
45-00-211	5	Hudnut	1										7		18						1	1164
45-00-214	1	Coyote Creek	2					1					2		3							628
45-00-214	2	Coyote Creek	2	3				1			2	1	15		6						1	3181
45-00-214	3	Coyote Creek	2	1	1						3		30	7	14		1				2	5713
45-00-214	4	Hudnut	3	4							2		39	8	11		2	1		7		5549
45-00-242	1	Coyote Creek	2	1									21		32						1	2065
45-00-242	2	Coyote Creek	2	4		1	1			1			17	4	10					3		987
45-00-242	3	Hudnut	1	3			2				2		10	8	14					1	1	1607
45-00-242	4	Karter	3								2		23	17	25						8	4325
45-00-243	1	Coyote Creek	3											1							1	104
45-00-243	2	Hudnut	2										1	1	2							520
45-00-243	3	Hudnut	2										4	3	15							845
45-00-243	4	Karter	3										1		4							619
45-00-273	1	Coyote Creek/	3	2										2	2							213
		Karter											2	3	3							455
45-00-273	2	Coyote Creek	3	9																		0
45-00-273	3	Karter	3	5			1				2		9	6	6							1037
45-00-273	4	Karter	3								2	1	13	7	7	1						1926
45-00-273	5	Karter	3	2							1		1	1								236
45-00-282	1	Karter	3						1						1							112
45-00-282	2	Karter	3		2				2	1			10	3								855
45-00-282	3	Karter	3	7					1	2	1		13	4								1150
45-00-282	4	Karter	3	2					2		2		16	7								1972
45-00-282	5	Mixed	3	7									5	1								485
45-00-285	1	Coyote Creek	3	10									21	14	5							1564
45-00-285	2	Coyote Creek	3								3		25	1	8		1					11354
45-00-285	3	Hudnut	3	8		1			1	3	1		9	2								4370
45-00-285	4	Hudnut	3	2							1		39	1	8							1504
45-00-326	1	Coyote Creek	2	4					1		1		26	4	4							3649
45-00-326	2	Coyote Creek	3	7	1				1		2		4	1	2			1				1995
45-00-326	3	Hudnut	2	1		1					1		4		2							1791
45-00-326	4	Hudnut/Karter	3	2							1		6		4						1	2037
45-OK-2	1	Coyote Creek	1	6	1		7	3	2		3		6	1	1							1325
45-OK-2	2	Coyote Creek	1	10	1	2	6	5	2		5		110	11	92	2		2	7	6	10	23216
45-OK-2	3	Hudnut	1	13		2	5	1	1		3		97	11	127			1		4	15	17918
45-OK-2	4	Hudnut	2	4			1	1			3		54	9	101			5		3	12	9609
45-OK-2A	1	Coyote Creek	2								3		21	1	25			3			7	2850
45-OK-2A	2	Hudnut	1	1	1						2	1	6	1	4							1557
45-OK-2A	3	Karter	3										2	3	8							732
45-OK-2A	4	Karter	3	1										1	3							209
45-OK-4	S1	Coyote Creek	2	3		1		1			1			1								103
45-OK-4	S2	Hudnut	1	31		3	6		1	1	7		18	6	51						1	5507
45-OK-4	S3	Hudnut/Karter	3	1							6		29	8	148			5			14	12131
45-OK-11	A	Hudnut	2	32	7			4	2	2	1		2	2	6						4	1038
45-OK-11	B	Karter	1	50	10	9	6	22	2	1	15		76	12	69	1					8	23792
45-OK-18	1	Coyote Creek/	3	3							8		87	24	116	2		7		3	13	25129
		Hudnut											19	3	15						37	1864
45-OK-18	2	Hudnut	2	8																		
45-OK-18	3	Hudnut	3										18	5	30						79	3551
45-OK-18	4	Karter	3										7	2	2						11	885
45-OK-250	S1	Coyote Creek/	2	11	2		4	2														105
		Hudnut									1		49	9	91			4		2	24	6584
45-OK-250	S2	Hudnut	1	24	2		20	1														
45-OK-250	S3	Hudnut/Karter	2				1	1			5		64	13	105			6		1	30	10594
45-OK-258	A	Coyote Creek	1	32		5			3	2			5		8			2				739
45-OK-258	B	Hudnut	1	53	4	14		1			13		56	9	95		1				5	18221
45-OK-287/8	1	Coyote Creek	3	1							9		41	26	134						15	18829
45-OK-287/8	2	Coyote Creek	2	3	1					2			2									106
45-OK-287/8	3	Coyote Creek	1	5				1					2		6							441
45-OK-287/8	4	Coyote Creek/	2	6								1	17	7	22							1943
		Hudnut/Karter											16	7	15						1	1632
45-OK-287/8	5	Coyote Creek/ Hudnut/Karter	2	16		1		2		2	2	2	23	13	22							3078
45-OK-287/8	6	Karter	2	23				1		1		1	9	4	9					1		1943
		Totals		428	33	40	63	49	22	18	119	7	1261	300	1548	6	5	37	7	31	303	

Key to Traditional Type Abbreviations in Table D-5.

Abbreviation	Traditional Type	Abbreviation	Traditional Type
SHA	Shaft Abrader	HAM	Hammerstone
EGC	Edge-ground Cobble	PES	Maul/Pestle
UTF	Utilized Flake	HOP	Hopper-mortar base
BLA	Blade	MIL	Milling Stone
MIC	Microblade	ANV	Anvil Stone
FLB	Flaked Long Bone	BUR	Burin
ANS	Awl/Needle/Shuttle	BSP	Burin Spall
DRI	Drill	GRA	Graver
PPT	Projectile Point	SPO	Spokeshave
BPH	Bone Point/Harpoon	URT	Unifacially Retouched Flake
CHO	Chopper	SCR	Scraper
PFC	Peripherally Flaked Cobble	TKN	Tabular Knife
ADZ	Adze	NET	Netsinker
CHZ	Chisel	PIP	Pipe
WEG	Wedge	SHO	Shell Ornament
DEB	Debitage	COO	Copper Ornament
BCR	Blade Core	BOO	Bone Ornament
FKR	Antler Flaker/Billet	STO	Stone Ornament

Table D-6. Faunal inventories by site/component.

Site	Zone	Phase	Feature Site Type	Number of Identified Specimens by Taxon[1]													
				Sor	Lep	Syl	Mar	Spe	Tho	Per	Cas	Pmy	Neo	Mic	Lag	Ond	Cri
45-00-204	1	Coyote Creek	2							2		1					
45-00-204	2	Hudnut	3		1		3		1					2	2		
45-00-204	3	Kartar	3		1		1								1		
45-00-204	4	Kartar	3						7	9		1		1	5		
45-00-211	1	Historic	3														
45-00-211	2	Hudnut	3				1	4	47	14		1		7	16		
45-00-211	3	Hudnut	3		1		11	4	72	20				2	9		
45-00-211	4	Hudnut	1		1		8	2	96	10		2			6		
45-00-211	5	Hudnut	1	1		2	5	3	58	6				1	4		
45-00-214	1	Coyote Creek	2		2			1	12	8					5	1	
45-00-214	2	Coyote Creek	2				11	3	15	18		4		7	4		
45-00-214	3	Coyote Creek	2		2	1	11	9	7	10				5	8		
45-00-214	4	Hudnut	3				31	53	68	9	5	2			6		
45-00-242	1	Coyote Creek	[illegible]			3			3	4					3		
45-00-242	2	Coyote Creek	2				3			2	1						
45-00-242	3	Hudnut	1				21		32	1	3	1					
45-00-242	4	Kartar	3				1		11								
45-00-243	1	Coyote Creek	3				1										
45-00-243	2	Hudnut	2				2		12			1					
45-00-243	3	Hudnut	2				6		43			1					
45-00-243	4	Kartar	3				10		36	2							
45-00-273	1	Coyote Creek/ Kartar	3							1					8		
45-00-273	2	Coyote Creek	3						13						1		
45-00-273	3	Kartar	3				1	1	11	3							
45-00-273	4	Kartar	3				1		17								
45-00-273	5	Kartar	3						13	1							
45-00-282	1	Kartar	3			2			15	7					6		
45-00-282	2	Karter	3			1	2		40	34			1		2		
45-00-282	3	Kartar	3				2		104	9		1	1	1	2		
45-00-282	4	Kartar	3						150	5		2			1		
45-00-282	5	Mixed	3				5		18						1		
45-00-285	1	Coyote Creek	3				6	1	35	43		4		3	12		
45-00-285	2	Coyote Creek	3				1	1	40	15		1		2	15		
45-00-285	3	Hudnut	3	2	1		15	1	64	18		1		1	3		
45-00-285	4	Hudnut	3				31		84	2				2	8		
45-00-326	1	Coyote Creek	2			5	13	6	9	5		1		1	8		
45-00-326	2	Coyote Creek	3		1	4	42	1	17	7		2	1	1	3		
45-00-326	3	Hudnut	2				49	2	6			3	2	1	4		
45-00-326	4	Hudnut/Kartar	3			1	107	1	63	1		3	1	1	3		
45-OK-2	1	Coyote Creek	1				13		3	5		1			1		
45-OK-2	2	Coyote Creek	1				12		63	57	4	2	2	5	4		
45-OK-2	3	Hudnut	1		2				93	28	2	8			2		
45-OK-2	4	Hudnut	2		4		2		120	20		3		4			
45-OK-2A	1	Coyote Creek	2		1		1		1	1		1					3
45-OK-2A	2	Hudnut	1						19	18					2		
45-OK-2A	3	Kartar	3				1		12	3				1			
45-OK-2A	4	Kartar	3				1		20	3							
45-OK-4	51	Coyote Creek	2				3		5	12		3					
45-OK-4	52	Hudnut	1				8	1	72	34	1	7		6	1		
45-OK-4	53	Hudnut/Kartar	3				1		44	13							
45-OK-11	A	Hudnut	2		2		60	2	60	91	5	4	1	1	3		6
45-OK-11	B	Kartar	1		14		255	6	507	244	9	14		14		1	68
45-OK-18	1	Coyote Creek/ Hudnut	3				1			1							
45-OK-18	2	Hudnut	2				1		9	5		1		2	3		
45-OK-18	3	Hudnut	3				1		4	1							
45-OK-18	4	Kartar	3						1	1							
45-OK-250	51	Coyote Creek/ Hudnut	2				1		15	18		3		1			
45-OK-250	52	Hudnut	1	1		1	4	2	72	46		15		1			
45-OK-250	53	Hudnut/Kartar	2				3	2	62	5		1		2			
45-OK-258	A	Coyote Creek	1				10		31	29	1	5		3	3		1
45-OK-258	B	Hudnut	1		2		7	2	107	90	3	24		6	1		
45-OK-287/8	1	Coyote Creek	3														
45-OK-287/8	2	Coyote Creek	2														
45-OK-287/8	3	Coyote Creek	1							3			1				
45-OK-287/8	4	Coyote Creek/ Hudnut/Kartar	2				4		13	1	1					4	
45-OK-287/8	5	Coyote Creek/ Hudnut/Kartar	2				1		1		1					15	
45-OK-287/8	6	Karter	2						18	1						1	

Table D-6, cont'd.

Site	Zone	Phase	Feature Site Type	Number of Identified Specimens by Taxon[1]												
				Cla	Clu	Cfa	Can	Vul	Urs	Lut	Mra	Mrp	Mus	Tax	Mep	Lyn
45-DO-204	1	Coyote Creek	2													
45-DO-204	2	Hudnut	3										1			
45-DO-204	3	Kartar	3													
45-DO-204	4	Kartar	3													
45-DO-211	1	Historic	3													
45-DO-211	2	Hudnut	3				1									
45-DO-211	3	Hudnut	3											1		
45-DO-211	4	Hudnut	1	1												
45-DO-211	5	Hudnut	1				1						3			
45-DO-214	1	Coyote Creek	2													
45-DO-214	2	Coyote Creek	2				2									
45-DO-214	3	Coyote Creek	2											1		
45-DO-214	4	Hudnut	3													
45-DO-242	1	Coyote Creek	2										1			
45-DO-242	2	Coyote Creek	2			3										
45-DO-242	3	Hudnut	1			8	14									
45-DO-242	4	Kartar	3													
45-DO-243	1	Coyote Creek	3				1									
45-DO-243	2	Hudnut	2													
45-DO-243	3	Hudnut	2													
45-DO-243	4	Kartar	3				2									
45-DO-273	1	Coyote Creek/ Kartar	3				6									
45-DO-273	2	Coyote Creek	3													
45-DO-273	3	Kartar	3													
45-DO-273	4	Kartar	3													
45-DO-273	5	Kartar	3													
45-DO-282	1	Kartar	3													
45-DO-282	2	Kartar	3													
45-DO-282	3	Kartar	3													
45-DO-282	4	Kartar	3													
45-DO-282	5	Mixed	3				2							1		
45-DO-285	1	Coyote Creek	3													
45-DO-285	2	Coyote Creek	3				1									
45-DO-285	3	Hudnut	3				1							1		
45-DO-285	4	Hudnut	3				2									
45-DO-326	1	Coyote Creek	2											2		
45-DO-326	2	Coyote Creek	3				1							2		
45-DO-326	3	Hudnut	2													
45-DO-326	4	Hudnut/Kartar	3				4							53		
45-OK-2	1	Coyote Creek	1							7						
45-OK-2	2	Coyote Creek	1				5									1
45-OK-2	3	Hudnut	1				5		1							
45-OK-2	4	Hudnut	2				1									1
45-OK-2A	1	Coyote Creek	2													
45-OK-2A	2	Hudnut	1													
45-OK-2A	3	Kartar	3													
45-OK-2A	4	Kartar	3													
45-OK-4	51	Coyote Creek	2													
45-OK-4	52	Hudnut	1				4									
45-OK-4	53	Hudnut/Kartar	3				1									
45-OK-11	A	Hudnut	2		1		17	1	1							2
45-OK-11	B	Kartar	1	3	5		22		4		2			1	8	5
45-OK-18	1	Coyote Creek/ Hudnut	3													
45-OK-18	2	Hudnut	2													
45-OK-18	3	Hudnut	3													
45-OK-18	4	Kartar	3													
45-OK-250	51	Coyote Creek/ Hudnut	2				3									
45-OK-250	52	Hudnut	1				32									
45-OK-250	53	Hudnut/Kartar	2				2									
45-OK-258	A	Coyote Creek	1	1			24		2			4				
45-OK-258	B	Hudnut	1	1	1	110	31	5	2		5	3	1	1		
45-OK-287/8	1	Coyote Creek	3													
45-OK-287/8	2	Coyote Creek	2													
45-OK-287/8	3	Coyote Creek	1													
45-OK-287/8	4	Coyote Creek/ Hudnut/Kartar	2				2									
45-OK-287/8	5	Coyote Creek/ Hudnut/Kartar	2				5									
45-OK-287/8	6	Kartar	2													

Table D-6, cont'd.

			Feature							Number of Identified Specimens by Taxon[1]									
Site	Zone	Phase	Site Type	Equ	Cer	Odo	Ant	Ovi	Bis	Deer	Elk	Chr	Vlp	Col	Ran	Amb	Sal	Cyp	Cat
45-OO-204	1	Coyote Creek	2			2													
45-OO-204	2	Hudnut	3			2				3									
45-OO-204	3	Kartar	3			1						5							
45-OO-204	4	Kartar	3												6				
45-OO-211	1	Historic	3																
45-OO-211	2	Hudnut	3			6		1		2		4	1				33	1	
45-OO-211	3	Hudnut	3			22				4		13		7	1		126		
45-OO-211	4	Hudnut	1			12				26		4		24	2		858	1	7
45-OO-211	5	Hudnut	1			2				5					13		11		
45-OO-214	1	Coyote Creek	2			8	1	3	1	16	1	46	1		3		7	3	
45-OO-214	2	Coyote Creek	2			72	12	14	1	60	5	157			6		40	26	
45-OO-214	3	Coyote Creek	2		1	89	22	17		187	8	12					189	8	
45-OO-214	4	Hudnut	3		1	12		2	1	5	1	9					5		
45-OO-242	1	Coyote Creek	2			9		3		7		1					4		
45-OO-242	2	Coyote Creek	2			15	1	2		47									
45-OO-242	3	Hudnut	1		4	341	2	190		829	7	53					42		
45-OO-242	4	Kartar	3			4		2		10					2		8		
45-OO-243	1	Coyote Creek	3			8						2					2		
45-OO-243	2	Hudnut	2			11	1	4		7							9		
45-OO-243	3	Hudnut	2			12				8		5					21		
45-OO-243	4	Kartar	3			2	1			2							4		
45-OO-273	1	Coyote Creek/ Kartar	3		5														
45-OO-273	2	Coyote Creek	3		1	1													
45-OO-273	3	Kartar	3																
45-OO-273	4	Kartar	3																
45-OO-273	5	Kartar	3																
45-OO-282	1	Kartar	3			2				1		1					1		
45-OO-282	2	Kartar	3			1						2					2		
45-OO-282	3	Kartar	3									18					8		
45-OO-282	4	Kartar	3												1		3		
45-OO-282	5	Mixed	3			1					1	1							
45-OO-285	1	Coyote Creek	3		1	7		3		7	1	10			4		62	2	1
45-OO-285	2	Coyote Creek	3		1	8		1		2		4			2		11		
45-OO-285	3	Hudnut	3		9	13		8	7	14	9	6			114		9		
45-OO-285	4	Hudnut	3		6	7		3	5	14	9	3			47		5		
45-OO-326	1	Coyote Creek	2		1	63	2	15		88	5			4			6	2	
45-OO-326	2	Coyote Creek	3		4	23	28	37		86	2			6			2	1	
45-OO-326	3	Hudnut	2			5	1	6		28	2			25			10		
45-OO-326	4	Hudnut/Kartar	3		2	29		14		35	2			126	8		67		
45-OK-2	1	Coyote Creek	1	8	1	581	3	2		348	5	10		3	2		73	12	
45-OK-2	2	Coyote Creek	1		3	686	10	18		616	3	42		80	7		104	6	
45-OK-2	3	Hudnut	1		6	275	2			321	10	16		5	3		90	1	
45-OK-2	4	Hudnut	2		1	475	1	31		345	3	9		5	3		134	6	6
45-OK-2A	1	Coyote Creek	2			20				35							4	1	
45-OK-2A	2	Hudnut	1			63	5	187		137		11		1			133		2
45-OK-2A	3	Kartar	3			4				17		4		21	2		79		1
45-OK-2A	4	Kartar	3							6				6			9		
45-OK-4	51	Coyote Creek	2			81		10		37	1	9					21	3	
45-OK-4	52	Hudnut	1		3	684	3	54		900	2	115		31			532	21	1
45-OK-4	53	Hudnut/Kartar	3		1	58		13		37		3					27	3	
45-OK-11	A	Hudnut	2		24	232	10	15	2	236	8	123		120	11		63	138	
45-OK-11	B	Kartar	1		24	1432	56	335	10	1815	19	331		90	61		276	522	
45-OK-18	1	Coyote Creek/ Hudnut	3																
45-OK-18	2	Hudnut	2							1		13		24					
45-OK-18	3	Hudnut	3									1					2		
45-OK-18	4	Kartar	3																
45-OK-250	51	Coyote Creek/ Hudnut	2			147		11		205	2	88	1	4			7		1
45-OK-250	52	Hudnut	1		1	487		4		701	1	116	2	72	1		159	10	
45-OK-250	53	Hudnut/Kartar	2			104		32		94		11		55			10		
45-OK-258	A	Coyote Creek	1	19	4	1496	28	344		2636	8	18		10		35	20	7	
45-OK-258	B	Hudnut	1		10	1844	11	165		2799	8	56		70	44	40	65	33	
45-OK-287/8	1	Coyote Creek	3			1				23	2								
45-OK-287/8	2	Coyote Creek	2			13	11	4		46							2		
45-OK-287/8	3	Coyote Creek	1			114	37	16		277	1				1		5		
45-OK-287/8	4	Coyote Creek/ Hudnut/Kartar	2			60	7	359		120							4		
45-OK-287/8	5	Coyote Creek/ Hudnut/Kartar	2			64	35	4		153		17							
45-OK-287/8	6	Kartar	2			26	2	8		24							4		

Key to Abbreviations of Taxonomic Names in Table D-6

Abbreviation	Taxon	Abbreviation	Taxon
Sor	*Sorex* spp.	Mrp	*Martes pennanti*
Lep	*Lepus* cf. *townsendii*	Mus	*Mustela frenata*
Syl	*Sylivagus* cf. *nuttallii*	Tax	*Taxidea taxus*
Mar	*Marmota flaviventris*	Mep	*Mephitis mephitis*
Spe	*Spermophilus* spp.	Lyn	*Lynx rufus*
Tho	*Thomomys talpoides*	Equ	*Equus caballus*
Per	*Perognathus parvus*	Cer	*Cervus elaphus*
Cas	*Castor canadensis*	Odo	*Odocoileus* spp.
Pmy	*Peromyscus maniculatus*	Ant	*Antilocapra americana*
Neo	*Neotoma cinerea*	Ovi	*Ovis canadensis*
Mic	*Microtus* spp.	Bis	*Bison bison*
Lag	*Lagurus curtatus*	Deer	Deer-sized
Ond	*Ondatra zibethica*	Elk	Elk-sized
Eri	*Erithizon dorsatum*	Chr	*Chrysemys* cf. *picta*
Cla	*Canis latrans*	Vip	Viperidae
Clu	*Canis lupus*	Col	Colubridae
Cfa	*Canis familiaris*	Ran	Family Ranidae/Bufonidae
Can	*Canis* spp.	Amb	Amphibia
Vul	*Vulpes vulpes*	Sal	Salmonidae
Urs	*Ursus* spp.	Cyp	Cyprinidae
Lut	*Lutra canadensis*	Cat	Catastomidae
Mra	*Martes americana*		

APPENDIX E:
HISTORICAL AERIAL PHOTOGRAMMETRY AND HABITATION SITE DISTRIBUTION

by Lawr V. Salo

Since the early 1970's, a major program of archaeological survey and data recovery has been carried out first by the National Park Service and then through Seattle District, Corps of Engineers (Corps), at the Chief Joseph Dam project on the Columbia River in north-central Washington State. Some reconnaissance and small-scale data recovery had taken place in the later 1940s and early 1950s before the dam was constructed. Work thus far has identified around 178 prehistoric archaeological habitation sites in a 45-mile reach of the river from River Mile (RM) 545 to RM 590 (Appendix D, Figure D-1). Approximately half these sites have been tested; intensive data recovery has been carried out at 24 of them. Surveys by the Corps and the University of Washington in the late 1970s (Munsell and Salo 1977, Leeds et al. 1981) found that earlier work recorded only a small percentage of the sites actually present, and tended to concentrate on the most recent occupation in the areas with easiest access. The south bank of the river had been virtually uninvestigated, and low lying terraces along the downstream third of the reservoir received scant attention. The south bank has since been thoroughly investigated where it is above water, but the low terraces in the downstream part now are permanently and deeply inundated by Rufus Woods Lake, the power pool behind Chief Joseph Dam, and cannot be inventoried by conventional on-the-ground techniques.

The first study of site distributions in the project area suggested that the apparent lack of prehistoric habitation sites in the lower part of the reservoir might be due to the great likelihood of site inundation in this area, where the reservoir is deepest, approximately 150 feet deep (Leeds, Chapter 7). Because we are undertaking a major effort towards understanding prehistoric land use and settlement patterns at the project, we decided to employ all practical means to account for biases in the archaeological records that will be used to develop models. Therefore, we searched for aerial photographs of the reach taken before the first dams had been constructed in hope of identifying the locations and extent of permanently flooded landforms that elsewhere in the area have associated archaeological sites. We also believed it might be possible to locate previously unrecorded housepits and housepit-marked sites in many instances, especially those reported by informants but not confirmed. The extent to which erosional damage had introduced biases into characterizations of known sites also might be established. Finally, it seemed appropriate to search for housepits where none yet have been found. The permanently inundated lower one-third of the reservoir and the lowest flood plains and terraces throughout the reservoir were of particular interest; the lower part of the reservoir because few if any housepits had been recorded, and the low-lying landforms because so little of this area had been available anywhere in the reservoir during recent on-the-ground inspections.

METHODS

We found only one complete series of pre-impoundment aerial stereophotographs of the reservoir. Flown in March 1930, these are 5 x 5 inch black and white positive prints at scale 1:22,500 (flown at 11,250 feet above mean terrain). The Seattle District file number for this series is B630-2; photographs D-165 through 200 and E-1 through 10 provide full stereo coverage for the Chief Joseph Dam Project reach. This series continuously covers the Columbia River from Pasco, Washington to the Canadian border some 420 miles upstream, although prints for some reaches are missing from the files. The prints on file at the Seattle District office are the only existing copies: the negatives and other prints were destroyed by fire in the 1940's. This series is especially useful because the area had not yet revegetated fully after overgrazing in the late 19th and early 20th centuries and surface exposures are good.

Observation consisted of viewing stereo pairs through a ten power stereoscope. As a calibration exercise, well-documented examples of housepits of different sizes, shapes, and depths at sites 45-OK-2A, 45-OK-20, and 45-OK-239 were examined. Deep housepits were seen as distinct shadows; shallower specimens often were identifiable by lusher (darker) vegetation, especially in house depressions where slackwater sediments had accumulated as at 45-OK-2A. Next, other known housepit sites were inspected and houses identified on the photograph were noted. Notes were made on 15 minute (1:62,500) USGS contour maps (Bridgeport, Boot Mt., Alameda Flat, Nespelem, and Grand Coulee Dam quadrangles). We then carried out a preliminary census of relatively level inundated landforms, divided into 50-100 ft above ordinary high water, low (0-50 ft above ordinary high water). Landform locations were recorded on 15 minute contour maps and received provisional site numbers (45-OK/DO-PSOC-N). Finally, we reviewed the stereo pairs to locate previously unrecorded housepits. The locations of identified examples were marked on the 15 minute base maps and these housepit sites were assigned provisional site numbers (45-OK/DO-PSHP-N).

RESULTS

The search was unexpectedly successful at locating new housepit sites (Table E-1, Figure E-1). Twelve definite housepit sites with single or multiple housepits, marked by deeply shadowed depressions, were found. Less deeply shadowed pits or vegetation differences indicated one or more housepits

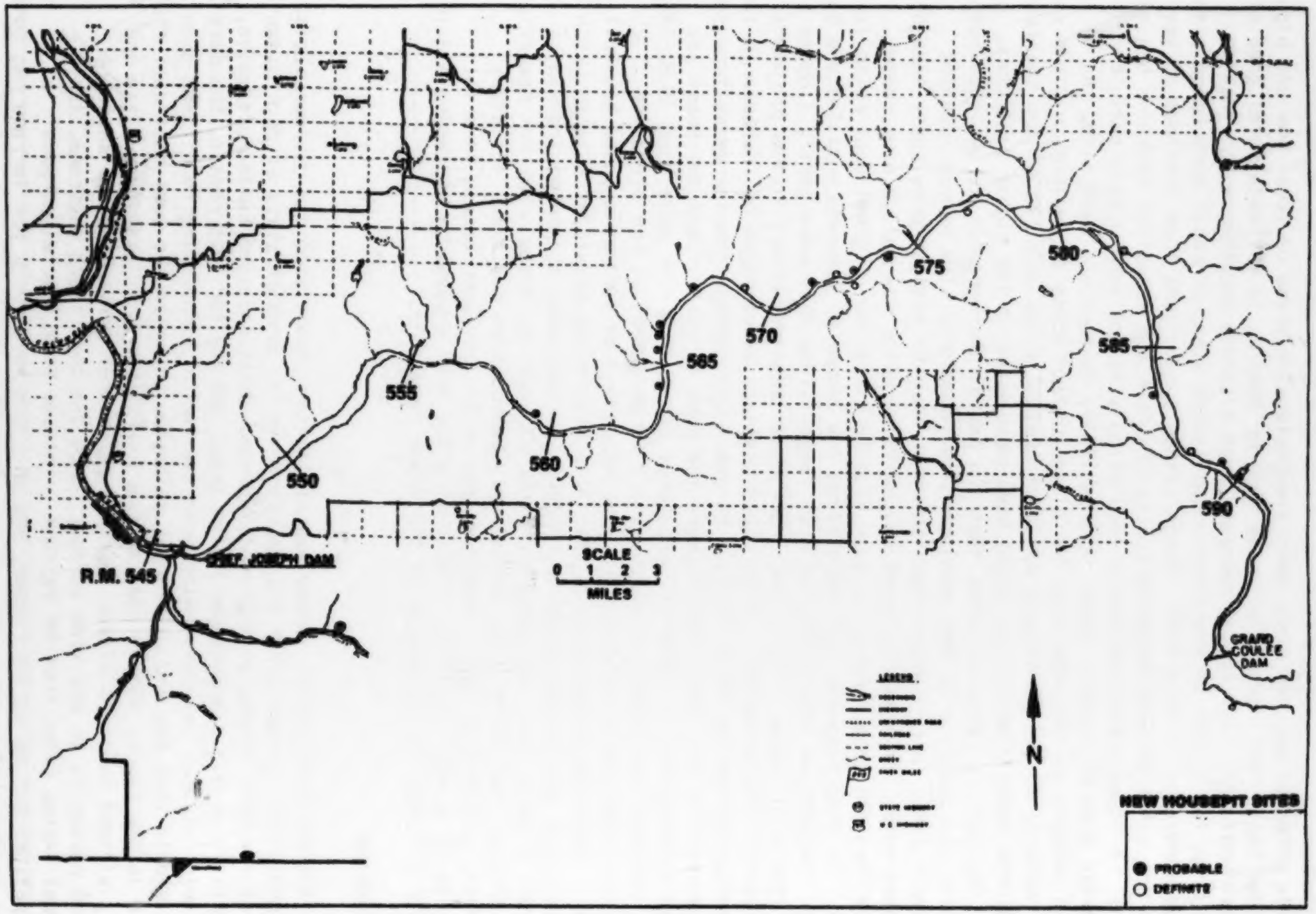
R.M. 545
CHIEF JOSEPH DAM
550
555
560
565
570
575
580
585
590
GRAND COULEE DAM
SCALE
0 1 2 3
MILES
N
NEW HOUSEPIT SITES
PROBABLE
DEFINITE

Figure E-1. New housepit sites.

at six other sites. We also identified extensive areas of level low and high flooded landforms. We did not have time or funding to estimate total area of these landforms, but instead recorded each discrete occurrence and then estimated the number of prehistoric habitation sites probably associated with these landforms (Figure E-2). Rough linear projections from previous survey data suggest that each topographically discrete low elevation landform has at least one associated prehistoric habitation site and most likely more. Each discrete area of higher, level land is likely to have one such site. As a rough measure of the potential for sites without house depressions visible on the surface, we conservatively estimate that 20 sites occurred on all the low landforms identified and 13 would have been found on the higher landforms.

The data in Table E-1 show that the aerial photographic survey adds both quality and quantity to the previous site inventory. The survey revealed housepit sites in a 10-mile reach of river from RM 559-565 previously thought to have none. It also disclosed housepits at sites now called open camps, where they had been removed by bank erosion since the original pool raise in 1956. It also suggests that many sites now shown as separate entities are but minor remnants on high ground of much larger sites that were partly flooded by the 1956 pool raise. The survey also added comprehensively to the project's habitation site inventory. Figure E-3 displays percentages of increase in the inventory by 5-mile reach groups. As one might expect, the increases tend to be greatest in the lower reaches were the pool is deepest and the least was known previously. A comparatively large increase in the upper pool (R.M. 585-590) probably is related to an unusually large extent of low elevation surface, combined with an overall low percentage of surface-exposed housepit sites. These data also suggest that site clustering exists at a large scale (Figure E-4) and probably can be related to functional and/or environmental factors (Figure E-5). As noted by Leeds (Chapter 7), areas with the fewest of any kind of habitation sites are steeply banked with few minor tributary streams, poor winter solar exposure, and relatively poor access to a full variety of upland resources. Housepit sites that supposedly represent stable winter villages do not appear in the lower reservoir.

DISCUSSION

Stereo photographic survey has limitations apart from the obvious limits of resolution, ground cover and exposure. In its present state of development at the project, stereo photographic survey cannot disclose buried housepits, relatively common phenonomena in the area. Partly for this reason, the data in Table E-1 must be viewed with some caution in formulating hypotheses about prehistoric land use and settlement patterns. However, we feel confident that there is one reach, RM 545-554, with a low frequency of prehistoric use and truly without housepit sites. Testing at several sites here has shown no buried housepits in any time period. From the next reach upstream, the several tested sites from RM 555-564 include some special-purpose occupations but no buried houses, and only one house on a low terrace has been found in the photography. We conclude that this reach also was relatively

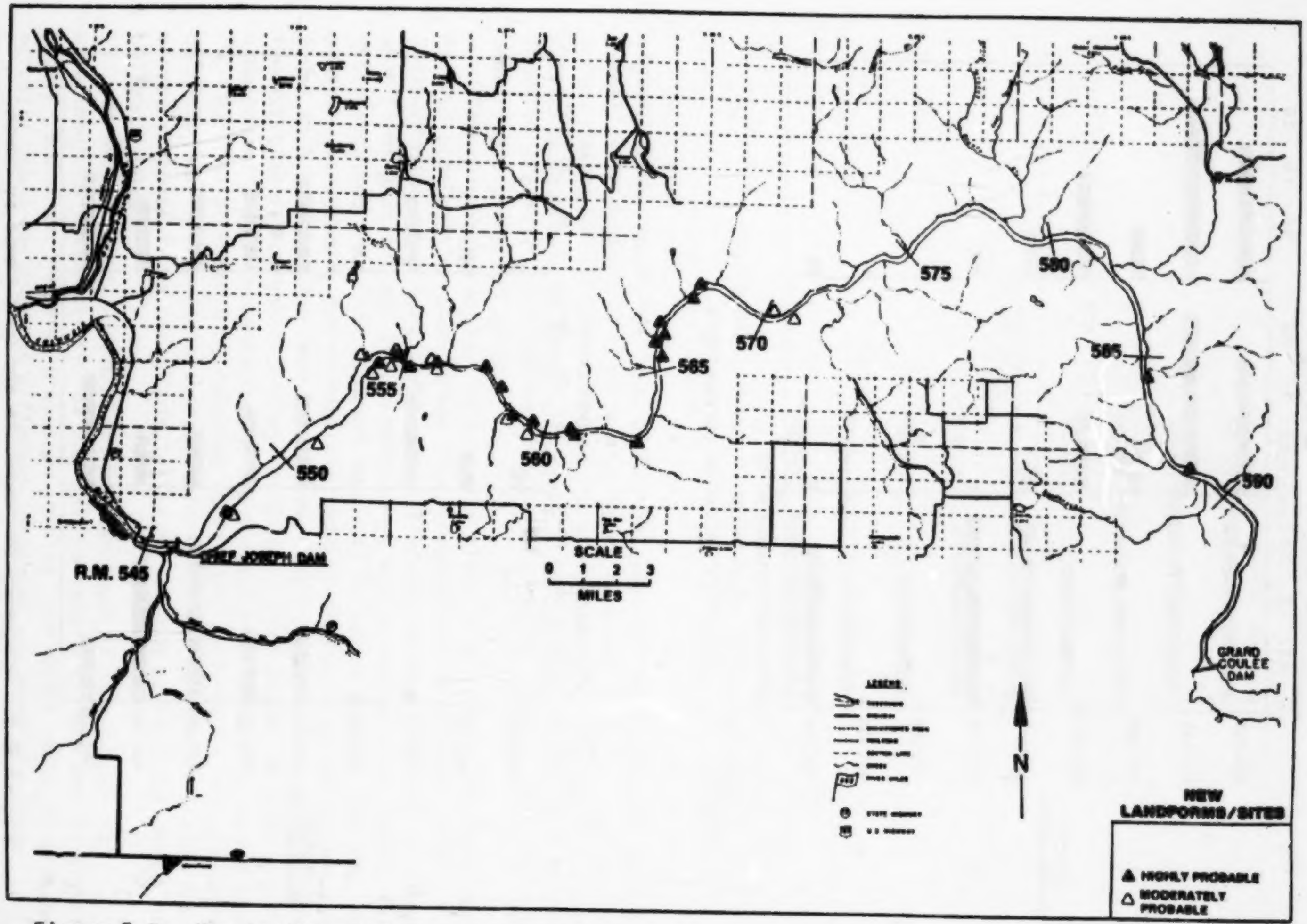
R.M. 545
CHIEF JOSEPH DAM
550
555
560
565
570
575
580
585
590
GRAND COULEE DAM
SCALE
0 1 2 3
MILES
N
NEW LANDFORMS/SITES
▲ HIGHLY PROBABLE
△ MODERATELY PROBABLE

Figure E-2. New landforms/sites.

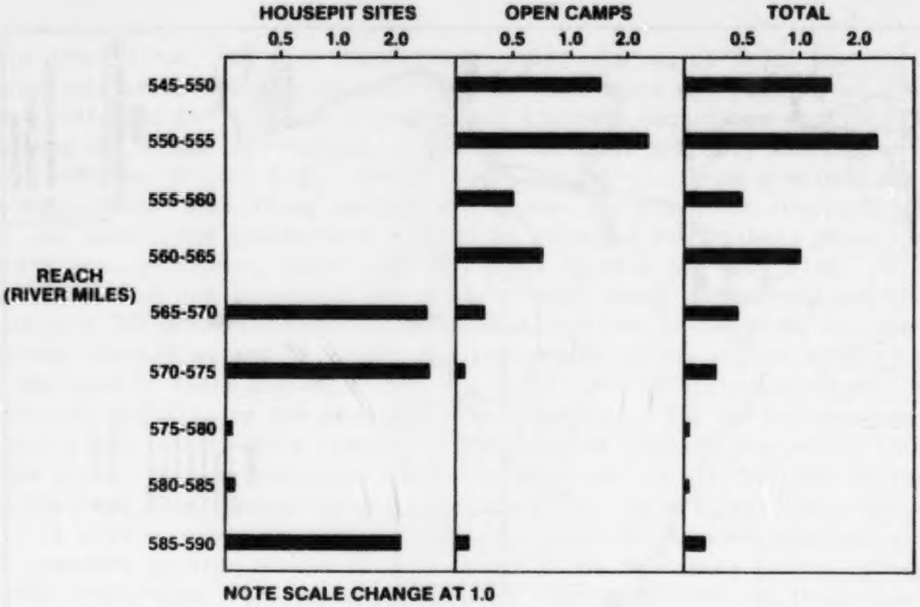

Figure E-3. Inventory increase percentages.

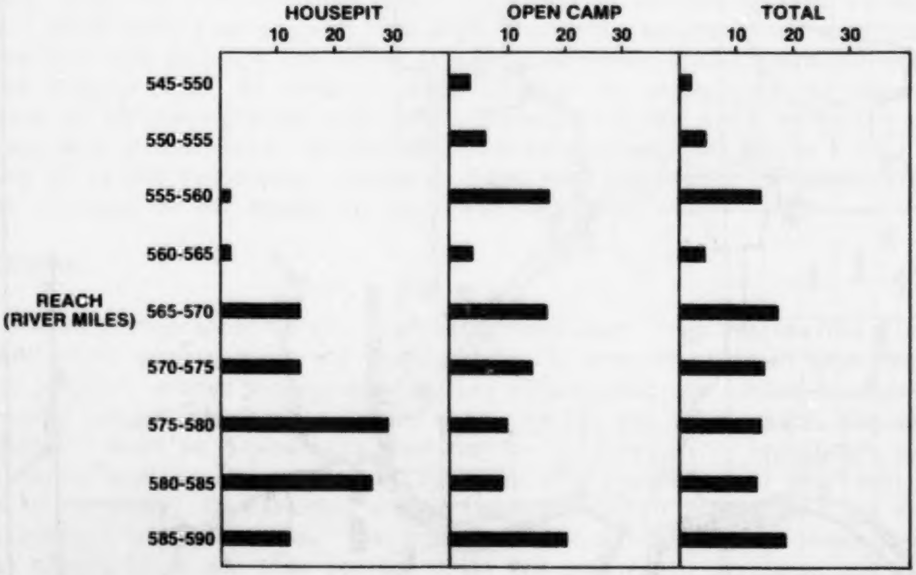

Figure E-4. Frequency of housepits and open camps by reach.

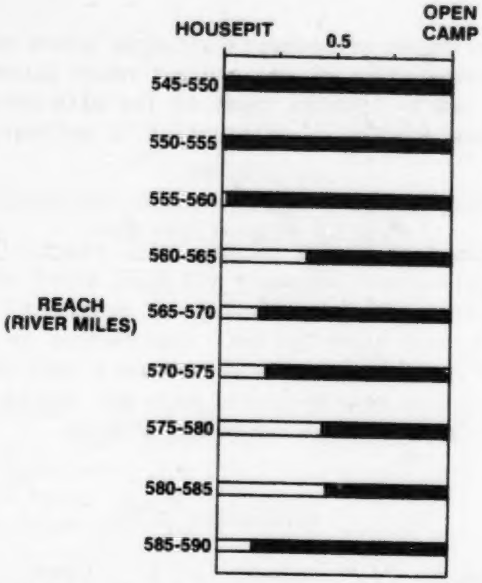

Figure E-5. Housepit/open camp ratios by reach.

lightly used. Above R.M. 564, buried and unburied housepits are common, overall site density is high, winter solar exposure usually is good, and access to a wide variety of upland (forest and steppe) and lowland riverine resources generally is good. The reach from R.M. 564 to 590 thus is a true focus of habitation and represents one large-scale cluster, at least from about 5,000 years ago onward.

The observed frequency of housepit sites in a given river reach may reflect preservation bias rather than frequency of prehistoric use. Sedimentation rates vary greatly in different reaches of the river, depending upon river gradient and canyon morphology and at currents and bends, velocity and direction, etc. The apparent scarcity of houses in R.M. 585-590, for example, is probably due to high sedimentation rates. Buried houses have been found at 5 of 35 tested open camp sites. More rigorous and detailed study of the existing photographic coverage of known buried houses or even digital enhancement might be warranted to develop means of detecting buried houses.

Further discussion of land/use settlement patterns in the project area, chronologically ordered is needed. Unfortunately, the aerial photographic survey at present can contribute little as surface depressions cannot be reliably dated.

We suspect that the rough projections used in this report for site/landform frequency are low for the low landforms, but may be high for the higher landforms. Greater precision in site estimates could be produced by actually neasuring areas of different landforms and more precisely extrapolating from density figures developed by the on-the-ground surveys, but the results of such a project may not be worth the cost. For example, in addition to the disclosure of housepit villages where none previously were known, the chief contribution of the present rough survey is the graphic demonstration of a nearly 15-mile reach of low site density, a qualitative datum upon which more precise quantification is unlikely to improve.

CONCLUSION

The use of historical aerial photographic imagery at the Chief Joseph Dam project has disclosed several housepit villages where none previously were known, and has added to general knowledge of prehistoric habitation site character, condition, and distribution. Limitations in method notwithstanding, it shows promise in preliminary land use/settlement pattern studies, especially where on-the-ground data are scarce and extensive areas are inundated or otherwise unavailable for studies.

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APPENDIX F:
RESEARCH DESIGN FOR INVESTIGATION OF LITHIC MATERIAL SOURCES AND PRELIMINARY RESULTS

by Lawr V. Salo

The draft research design for the Chief Joseph Cultural Resources Project (Jermann et al. 1980) identified significant research topics, formulated several hypotheses, and specified means (analytic systems) that would be used to test them. Among the analytic systems was a lithic technological classification proposed to collect data that could be used to investigate the ways in which tools were produced in different time periods or environmental contexts within the study area. One dimension in the classification was lithic material type, of which 40 distinctions were recognized. It was suggested that information on material type could be used to investigate possible quarry areas, prehistoric trade networks, etc., as well as functional preferences for materials.

The lithic classification proposed in the research design has several weaknesses. First the proposed material distinctions required greater mineralogical expertise than available among current staff if consistent results were to be obtained. It was uncertain whether recording of the gross morphological subdivisions of cryptocrystalline quartz minerals (CCS) commonly designated "opal", "jasper", "chalcedony", etc., was meaningful or even necessary for the research topics as presented in the design. Second, there was doubt whether several other entire dimensions and modes were usetul, necessary, or efficient; this criticism originated mainly from the lack of background presentation in the research design.

Subsequently, we performed preliminary interpretive analyses to support the analytic systems for lithic material and manufacture stage or suggest areas where refinements could be made. Preliminary results of analyses were tabulated in 1981 to allow review of the lithic technological classification. At this time about 10 percent of the total recovered lithic assemblage had been analyzed. We made several generalizations from this data.

1. There are three major kinds of lithic materials from project sites: cryptocrystalline quartz (CCS), basalt, and quartzite (Table F-1). Three varieties of CCS occur: fibrous (chalcedony/carnelian/agate), granular (chert/jasper), and hydrated (opal) (see Hurlbut 1971 for definitions). The basalt ranges from fine-grained (which may actually be olivine, to coarse-grained. The quartzite comprises what is actually a mica-schist and a coarse-grained variety.

Table F-1. Tabulation of lithic material type and dorsal condition of lithic flakes from selected excavation units.

	Lithic Material Type1/																Totals		
	1		2		3		4		5		6		7		39				
Site	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	Total
45-DO-204	8	372	4	230	11	19	2	21	4	8	0	0	1	36	0	0	30	686	716
45-DO-211	25	360	16	274	73	61	11	30	12	18	3	7	3	23	0	0	143	773	916
45-DO-214	150	2,867	25	917	6	19	5	30	3	20	0	0	1	27	0	0	190	3,880	4,070
45-DO-242	11	230	1	121	8	4	2	20	4	1	0	0	0	2	0	0	26	378	404
45-DO-243	8	233	4	57	5	7	3	14	2	2	0	0	0	13	0	0	22	326	348
45-DO-273	47	270	27	206	7	22	1	11	3	5	1	1	1	1	0	1	87	517	604
45-DO-282A	0	86	0	15	0	1	1	2	0	2	0	0	0	0	0	0	1	106	107
45-DO-285	224	4,255	14	717	19	38	8	29	9	28	3	2	2	7	0	0	279	5,076	5,355
45-DO-326	4	28	5	22	0	1	0	0	0	0	0	0	0	0	0	0	9	51	60
45-OK-11	4	638	0	68	11	19	21	13	73	59	3	1	3	69	0	0	115	867	982
45-OK-18	90	1,660	11	349	2	8	4	14	3	10	0	0	2	60	0	0	112	2,101	2,213
45-OK-250	1	50	0	16	2	1	1	0	0	0	0	0	0	1	0	0	4	68	72
45-OK-258	119	3,710	17	1,316	16	34	3	34	26	28	1	0	1	63	0	0	183	5,185	5,368
45-OK-287	0	18	0	1	3	0	0	0	0	0	0	0	0	0	0	0	3	19	22
45-OK-288	1	55	1	32	8	13	1	4	1	1	0	0	1	3	0	0	13	108	121
TOTAL	692	14,832	125	4,341	171	247	63	222	140	182	11	11	15	305	0	1	1,217	20,141	21,358

1/Material type: 1 = Jasper; 2 = chalcedony; 3 = coarse-grained quartzite; 4 = fine-grained quartzite; 5 = basalt; 6 = granite; 7 = fine-grained basalt; and 39 = very fine-grained sandstone.

NOTE: Dorsal Condition: + = cortex present, and - = cortex absent.

2. The ratio of large flakes with cortex to smaller flakes without cortex varies considerably among project sites. High ratios of large CCS flakes with cortex, interpreted as evidence of the initial phase of manufacture are infrequent, occurring only at 45-DO-211, 45-DO-273, and 45-DO-326. In contrast, the ratio of large flakes with cortex to small flakes without cortex is relatively high for both basalt and quartzite at most of the sites. Cortex on CCS objects is generally not indicative of water rounded cobbles, as it is on basalt and quartzite.

3. Material frequencies and frequencies of cortex varied between the upriver and downriver ends of the reservoir and between the two banks of the river.

4. Exotic materials, i.e. fossilized (agatized or opalized) wood and obsidian were infrequent.

5. Larger or longer projectile points tended to be made of basalt or other non-CCS materials, at least in the late Kartar and early Hudnut Phases.

6. Formed CCS tools at the project may be somewhat smaller than their counterparts from other localities in the Plateau. They also appear to be made from materials with poor working qualities.

7. The average size of formed CCS artifacts appears to diminish from earlier to later occupations.

8. The numerical ratio of formed CCS artifacts to non-CCS flaked lithic tools may be lower at the project than in well-investigated areas farther downstream along the Columbia River (D. Rice, personal communication).

9. Finally, different kinds of lithic resources characterize different time periods--preliminary analysis suggests that preferences parallel trends in the lower Snake River drainage (H. Kennedy, personal communication).

The above observations were made to guide additional work. Whether they are more apparent than real must be demonstrated by careful quantitative analysis of each component. Several tentative interpretations were suggested for future evaluation.

The small size and evident poor quality of CCS lithic materials together with the ratio of CCS to non-CCS tools could suggest that good quality CCS materials may have been in relatively short supply. Mechanical factors in raw starting materials, such as nodule size and frequency of flaws, and/or intensive reconditioning of manufactured items may have contributed to the hypothesized size/quality and ratio characteristics.

It is interesting that so few obviously exotic materials are found in the current data sample. Possibly we have failed to recover or detect them, but more likely some other factor is responsible. However, little work has been accomplished in the Plateau (other than with obsidian) to establish what materials comprise "domestic suites" and thereby what "normal" ratios of exotic/domestic might be expected in given study areas.

Overall diminution seems to be a regional trend, and while large scale technological changes such as use of lighter projectiles may account for the trend in part, we wonder if more conservative technologies might have evolved to offset emerging resource shortages. If so, we might expect them earliest in the most severely stressed areas, of which the project may be one.

SCOPE OF STUDY

Because of the large amount of excavated material available and the number of questions raised by analysis of site assemblages, the project area is a fertile research area for study of lithic material sources. By a relatively minor effort, we might gain information about the lithic raw material resources available to the prehistoric inhabitatants and be able to demonstrate how the enironmental potential is reflected in lithic artifact technological systems.

Environmental reconstruction for lithic material sources is not fraught with the same pitfalls as other types of land-use studies. Biological disturbances introduced by Euro-Americans are not a significant bias in this type of study. However, geomorphological disturbances are a potential bias. Although some geological formations have undergone major reductions in recent years (riverbottoms), adequate exposures of most still are available, as fresh road cuts and overgrazing-caused erosion actually have increased numbers of exposures. More difficult to account for are the biases introduced by prehistoric and historic use of lithic resources and the burial of bedrock exposures by sedimentation.

The first goal of a series of studies of lithic sources should be to identify as many source locations as field and bibliographic search time permit; sources ideally should include prehistoric quarries as well as recent exposures, to obtain samples of data on quarrying procedures and unworked materials for experimental purposes, respectively.

The second goal is to identify and describe the mineralogical and lithic technological characteristics of materials from these sources.

The third goal is to generalize about the occurrence of these minerals in the study area; significant correlations with geological formations would be sought. Presumably the generalized occurrences also would reflect availability of technological features (ratios of jasper/chalcedony/opal, etc., in point sources or geologic formation which serve as source zones).

The final result of this study should be probabilistic statements about what kinds of lithic resources are available, in what amounts, and where. The level of accuracy at which the statements are made will depend on specific research needs and funding/effort that can be be brought to bear. If warranted, advanced technology can be brought into play to solve problems of mineralogical or lithological identity, as well as correlation of formations.

Below are presented the results of a very preliminary investigation. The first goal was addressed, in a non-quantitative manner, with respect to CCS alone. Preliminary work on other sources had been carried out by Hibbert (Appendix H). The search for CCS sources has been further pursued by Key and Cavazos (Appendix G).

PROCEDURES

A bibliographic search was conducted to locate published materials on (1) known source locations in the study area, (2) formation processes and physical/chemical characteristics of CCS minerals, and (3) investigations of the relationship between physical characteristics of lithic materials and tool requirements. Investigations also entailed interviewing persons with knowledge of local lithic materials and/or cultural resources and geology. Informants on occasion accompanied the investigator while visiting known quarry sites. These investigations were carried out in January and July 1981.

Field procedures involved automotive transects across basalt outcrops along roadsides as well as visiting reported sources. When lithic sources were encountered, small grab samples of materials were taken. Context of sources/materials was recorded in color and black and white photographs. Searched areas and sources were recorded on applicable U.S. Geological Survey (USGS) 7.5- and 15-minute maps. Information for each site included geodetic location by 1/64 section and elevation, presence of interbed materials, characteristics of matrix, possible associated flow members where sources occurred in basaltic context, and miscellaneous comments.

Quarry sites were distinguished on the basis of presence of hammerstones, large quantities of conchoidally fractured detritus, and antiquity of exposure or proximity to known prehistoric sites.

Minerals were identified by trained personnel in the Foundation and Materials Branch, Seattle District Corps of Engineers.

RESULTS

As a limited amount of data has been collected thus far, interpretations are restricted to tentative statements.

BIBLIOGRAPHIC RESEARCH

Bibliographic search disclosed few known CCS sources in north-Central Washington; opalized wood, common opal, and jasper are reported from the basalt flows in lower Grand and Moses Coulees (Ream 1977; Glover 1949). Only one CCS source is reported north of the Columbia River, blue agate found in a basalt formation (probably a dike or an Eocene submarine deposit) east of Tonasket (Ream 1977). CCS minerals are most likely to form under conditions where a porous or finely divided, freely soluble silicate matrix is subject to slightly acidic groundwater; sedimentation from aqueous solution usually occurs by replacement of less siliceous minerals or soluble substances, or by evaporation/precipitation in cavities (Dana and Ford 1961; Hurlbut 1971). The most suitable conditions appear to be in the Miocene basalts generally south of the project on the Columbia Plateau. Soluble silica is provided by the frequent deposits of soft fine lake and streambed sediments (interbeds) between flows, often with baked clay nodules and organic clasts, but also by the vesicles and other cavities that regularly occur at flow surfaces. Finally, the cooling of the flows produces a jointed surface, providing additional cavities as silica sources as well as pathways for rapid flow of groundwater. The rocks are high in free silica (SiO_2) content (Myers et al. 1979). In contrast, the Okanogan Highlands are composed largely of massive plutonic rocks of granodiorite and metasedimentary series (Pardee 1918). Cavities within these rocks are relatively infrequent, consisting mainly of a few vugs in diorite or granodiorite, which provide the most frequent opportunity in this kind of context for secondary development of quartz minerals, usually as large crystals. However, the outer surface of the vug often is lined with a finely crystalline to cryptocrystalline substance most closely resembling chert. It may serve as an occasional material source. Clasts in recent landforms at the project comprise another source.

FIELD EXAMINATION

Several sources of CCS materials were identified in Grand Coulee area (Table F-2). The closest to the Chief Joseph Project area itself was in basalt rim rock about 3 miles southeast of the Colville Indian Subagency. The remainder were all south of Elmer City, in the Upper Grand Coulee itself or in other canyons cutting the basalt plateau west and southeast of the town of Grand Coulee. The USGS maps indicating the locations are on file at the Seattle District Office, USCE.

Most of the specimens found were of poor quality, but several sources had opal and jasper nodules of usable size (Sites 2, 3, 5, and 10). Based on scattered flaked fragments, Sites 3 and 5 appear to be prehistoric quarry sites. Except for one specimen from Site 2 that weighed several kilograms, all specimens were fist-sized or smaller, usually with an opaline cortex and multiple faults. No sizable piece of chalcedony and no silicified (petrified) wood was located in the search areas.

DISCUSSION AND CONCLUSIONS

Even though our survey was limited in scope and not rigorous from a sampling standpoint, it is evident that the project vicinity is not well endowed with high quality CCS sources. Probably the best to date is the exhausted "Million Dollar Mile Quarry" (45-GR-) in the lower part of the upper Grand Coulee about 20-30 miles south of the project. Certainly, the abundance of CCS materials here does not begin to approach those available to the prehistoric inhabitants of the Vantage-Wenatchee area or the mid-Columbia in general. We would expect that a knapping industry dependent on local sources would emphasize conservative manufacturing and use practices, including use of alternative materials whenever possible.

Table F-2. Lithic material sources examined.

Site	Location	Elevation (feet)	Specimen	Identity	Weight (grams)
1	N1/2SE1/4NW1/4SW1/4 sec. 17, T. 28 N., R. 31 E., W.M.[1]	1,900 (approx)	1-1	chalcedony; yellow to gray; recrystallized opal	
			1-2	chalcedony; sedimentary chert; light gray with brown layers; dense	
			1-3	chalcedony; yellow; shrinkage cracks from dehydration from opal	
			1-4	chalcedony; yellow; recrystallized from opal; shrinkage cracks	78.8
2	N1/2NW1/4NE1/4 sec. 2, T. 28 N., R. 30 E., W.M.	1,800-2,000	2-1	chalcedony; brown waxy lustre and green dull surfaced; altered diatomite?	186.1
			2-2	opaline chalcedony; brown and green; recrystallized diatomite?	160.0
3	S1/2SE1/4 and S1/2SW1/4SE1/4 sec. 17, T. 30 N., R. 31 E., W.M.	2,480	3-1	opaline chalcedony (green) in limonite-cemented weathered volcanic glass (palagonite)	
			3-2	opaline chalcedony; white to yellow vitreous; may be recrystallized diatomite	
			3-3	chalcedony, brown	134.2
			3-4	chalcedony, limonite stained; heavy	36.1
			3-5	chalcedony, limonite stained throughout; heavy	71.2
			3-6	chalcedony, limonite stained throughout--outer surface of opal with shrinkage cracks	167.0
			3-7	opal; green translucent	8.3
			3-8	opaline chalcedony; yellow	10.7
			3-9	opaline chalcedony; yellow	9.0
			3-10	opaline chalcedony; yellow	7.8
			3-11	opaline chalcedony; dark green	2.6
			3-12	chalcedony; limonite stained; heavy	7.0
			3-13	opaline chalcedony; white to yellow vitreous	6.1
			3-14	chalcedony; brownish green, heavy	14.0
4	NW1/4NE1/4NE1/4 sec. 35, T. 29 N., R. 30 E., W.M.	1,880-2,000	4-1	chalcedony; brown limonite stained throughout; drusy vugs indicate open space filling; heavy	309.1
5	SW1/4SE1/4NE1/4NE1/4 and NW1/4NE1/4SE1/4NE1/4 sec. 24, T. 26 N., R. 28 E., W.M.	1,920	5-1	chalcedony; agate	36.3
			5-2	chalcedony opaline; white	10.1
			5-3	opaline chalcedony; vitrified diatomite?	6.6
			5-4	opaline chalcedony	4.7
			5-5	opaline chalcedony	10.4
			5-6	chert flint with jasper	18.1
			5-7	opaline chalcedony; yellow with brown bands	14.8
			5-8	agate chalcedony	33.9
			5-9	opaline chalcedony	5.9
			5-10	opaline chalcedony	13.5
			5-11	chalcedony; agate	7.6
			5-12	opaline chalcedony	17.0
			5-13	opaline chalcedony	6.9
			5-14	opaline chalcedony	7.0
			5-15	opaline chalcedony	5.0
			5-16	opaline chalcedony or agate	7.8
			5-17	agate chalcedony	2.5
			5-18	agate chalcedony	3.1
			5-19	opaline chalcedony	5.2
			5-20	chert flint	3.8

[1] Willamette Meridian.

Table F-2, cont'd.

Site	Location	Elevation (feet)	Specimen	Identity	Weight (grams)
			5-21	opaline chalcedony	10.1
			5-22	agate chalcedony	6.2
			5-23	agate chalcedony	2.6
			5-24	opaline chalcedony	1.5
			5-25	opaline chalcedony	4.3
			5-26	chalcedony	1.5
			5-27	chalcedony; opaline	4.1
			5-28	opaline chalcedony	1.2
			5-29	opaline chalcedony	2.8
			5-30	opaline chalcedony	3.7
			5-31	agate chalcedony	2.1
			5-32	opaline chalcedony	2.0
			5-33	jasper flint	3.6
			5-34	agate chalcedony	3.0
			5-35	sample missing?	3.3
			5-36	agate? chalcedony	1.1
			5-37	jasper	2.6
			5-38	chalcedony	1.1
			5-39	opaline	2.3
			5-40	opaline chalcedony	3.3
			5-41	agate? chalcedony	0.8
			5-42	agate chalcedony	1.5
			5-43	agate? chalcedony	1.2
			5-44	opaline chalcedony	2.2
			5-45	opaline chalcedony	1.6
			5-46	opaline chalcedony	3.1
			5-47	agate chalcedony	2.1
			5-48	flint-jasper	0.7
			5-49	jasper	1.0
			5-50	flint	1.2
6	N1/2NE1/4NW1/4SW1/4 sec. 32, T. 29 N., R. 29 E., W.M.	2,500	6-1	chalcedony with limonite stain throughout; dehydrated opal outer shell	28.3
			6-2	chalcedony with limonite stain throughout; dehydrated opal outer shell	170.2
7	N1/2NE1/4NW1/4NW1/4 sec. 25, T. 28 N., R. 31 E.	2,520	7-1	weathered basalt pillow lava	
			7-2	weathered basalt pillow lava	30.6
			7-3	weathered basalt pillow lava	22.0
8	E1/2SE1/4NW1/4SE1/4 sec. 23, T. 28 N., R. 31 E., W.M.	2,360	8-1	opal	316.5
			8-2	opal	
			8-3	opal	39.8
			8-4	opal	88.0
			8-5	opal	17.0
			8-6	opal	166.6
9	N1/2N1/2NE1/4NE1/4NW1/4 sec. 33, T. 29 N., R. 29 E., W.M.	2,370	9-1	opaline chalcedony (with pieces)	71.2
			9-2	opaline chalcedony	91.8
10	SE1/4NW1/4SE1/4SW1/4 sec. 18, T. 26 N., R. 29 E., W.M.	1,800	10-1	weathered basalt	194.1
			10-2	chalcedony	7.6
11	NE1/4NW1/4SW1/4SE1/4 sec. 35, T. 29 N., R. 30 E., W.M.	1,900	11-1	agate chalcedony	27.4
			11-2	agate chalcedony	26.5
			11-3	agate chalcedony	2.7

1/Willamette Meridian.

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APPENDIX G: SURVEY OF CRYPTOCRYSTALLINE QUARTZ SOURCES IN THE CHIEF JOSEPH DAM PROJECT AREA

By Susan E. Key and Valentina A. Cavazos

INTRODUCTION

The goal of this study was to locate and map sources of lithic materials found in the artifact assemblage of the Chief Joseph Dam Cultural Resources Project. Due to time limits imposed by the duration of this project and the large area to be covered, we focused on cryptocrystalline quartz (CCS) materials. This material type was abundantly utilized, according to the artifactual record, and, while other "exotic" materials such as petrified wood and obsidian are rare or nonexistent, CCS materials were definitely available to past residents of the project universe.

Prior to fieldwork, individuals with knowledge of known sources, potential source areas and past sitings of CCS materials were consulted. A field plan was devised based upon this information and also incorporating outcrops sited while en route. Literature on lithic sources in the project area was not available to the authors during the field study.

Fieldwork consisted of surveying the tops, slopes and bases of basalt outcrops searching for yellow-white cortex staining in the bedrock and/or dislodged chunks of CCS materials in the talus slopes below. Binoculars were used to inspect impassable basalt cliffs with the intent of siting cortex staining. When materials were found their approximate location was plotted upon USGS topographic maps and grab samples were taken.

RESULTS

The areas surveyed are indicated in Table G-1, grouped by USGS quad map titles and listed by survey site number. Information on survey technique and environment is included, as well as approximate elevation of site area, observed evidence, i.e. yellow-white cortex staining, which may indicate a possible environment of formation, and what type, if any, CCS materials were located. The USGS maps with locations marked on them are on file at the Seattle District Office, USCE.

Table G-1. Lithic material sources examined.

USGS Quad	Survey Site #	Survey Method	Site Description	Approximate Elevation	Evidence of CCS Formation	Type of CCS Materials Located	Comments
Grand Coulee	1	Binoculars	Basalt cliffs & talus slopes	2,400'	None	None	
	2	Pedestrian Survey	Basalt tablerock	2,400'	None	None	Encountered 3 rock features: 3'x4'x2' depressions @ base of upper talus slope. SE side of Sugarloaf Mountain overlooking [illegible] Basin.
Burt Rd.	3	Roadside find	Basalt plateau	2,400'	None	Whole cobble of very hydrated and fractured opal grading into poor quality chalcedony with cortex found lying on surface of south side of road bank. Further examination revealed a slightly scoriaceous flow top, but no staining or other evidence of ccs formation.	Cobble may have been exposed during road construction
	4	Pedestrian Survey	Basalt cliffs & talus slopes	2,500'	Some color	No CCS located despite coloration.	
	5	Binoculars	Basalt cliffs & talus slopes	2,500'	None	None	
	6	Pedestrian Survey	Basalt cliffs, talus slopes, glacially disturbed debris & plateau rim	1,800-2,300'	Much color, large cavities	No CCS located despite coloration in cavities	No direct evidence of mining during prehistoric times. Some cavities appeared chipped, possibly from modern gem collecting.
	7	Pedestrian Survey	Cliffs, talus & slopes between outcrops & plateau rim	2,000-2,400'	Some color	No CCS located despite coloration	
Nespelem	8	Pedestrian Survey	cliffs & talus slopes	2,400'	Some color	No CCS located despite coloration	
	9	Not Surveyed	Glacially & fluvially altered hillside	2,400'	None		Indicated by L. Fredin to contain chunks of ccs.
	10	Pedestrian Survey	Stream cut	2,400'	None	Chunks of medium grade opal and chalcedony with and without cortex; weathered from hillside. No basalt flows on same contour within sight, perhaps indicative of interbed.	Location indicated by L. Fredin
	11	Not Surveyed			Ethnographic		Source reported by L. Fredin.
Alameda Flat	12	Binoculars	cliffs	1,800-2,300'	None	None	
	13	Pedestrian Survey	Roa...t	2,200'	Staining from weathering Pillow basalt	None	
	14	Walking & Binoculars	Cliffs, talus slopes & flat area beneath cliffs	2,200'	None	None	
Electric City	15	Pedestrian Survey	Recent roadcut	1,800-2,100'	Abundant staining pillow basalt formation, large cavities in vesicular flow top	Opal and chalcedony found in situ; deposits grade from medium grade opal through chalcedony with weathered cortex to hydrated, slightly altered material.	
"Million Dollar Mile" Quarry	16	Pedestrian Survey	Stream cut in basalt plateau	+2,000'	Staining, pillow basalt formation	Chunks of very poor quality ccs found in fractures.	Extensive lithic scatter site located throughout area. Possible prehistoric quarry site. Small amounts of poor quality CCS were located on surface. Vertical stratigraphy may reveal large amounts of CCS and perhaps better quality material. Extent of buried CCS deposits unknown.

VARIETIES OF CCS

Several varieties of CCS materials appear to have been available for utilization. Of those varieties, opal and chalcedony seem to be most abundantly represented among the artifacts recovered in project excavations.

Chalcedony and opal are chemical sedimentary varieties of quartz which form by the action of silica laden ground water. The dissolved silica may originate from any quartz-bearing parent rock, sediment, or soil. However, free quartz, such as that which occurs in most sediments and soils, is in a form which is especially susceptible to surface weathering and leaching by ground water.

Although the formation of cc quartz minerals is not well documented, it appears that as water percolates over or through certain quartz-bearing substances, silica either goes into solution to be precipitated elsewhere, or is chemically converted into a form of CCS in situ. In both cases, a silica gel first forms which, with time, condenses to opal, an amorphous mineraloid containing a highly variable amount of H_2O. As excess H_2O evaporates or is driven off by increased pressure, the opal gradually recrystallizes to chalcedony, a fibrous variety of microcrystalline quartz which is differentiated by color, texture and luster. Since this process is ongoing, samples of various stages of dehydration may exhibit a minerological gradient from pure opal to pure chalcedony.

FORMATION CONDITIONS AND OCCURRENCE IN THE PROJECT AREA

Three conditions are required for the formation of these types of CCS mineraloid: 1) The presence of ground water which acts as a weathering agent and method of transport; 2) space in which deposition may occur; and 3) free silica. The basalt flows of the Columbia Plateau and Basin evidently meet these conditions, as chalcedony and opal, as well as other varieties of cc qtz, have been found throughout the region.

Four major subenvironments associated with CCS formation were noted during this survey of the project area:

1) Interbeds (which act as aquifers if ground water is present);

2) Cavities in flow tops (which may fill with silica precipitates);

3) Areas of pillow basalt formation;

4) Joints.

The interbeds between flows, which represent hundreds to thousands of years during which weathering forces dominated geological processes, provide fertile grounds for the development of free silica in the form of soil, sands, muds and other types of sediments. As a succeeding flow covered an area, these sediments were effectively encased in basalt and formed a permeable layer through which ground water could percolate.

The top portion of a basalt flow may in many cases be vesicular or scoriaceous due to gas bubbles which rise during the cooling process. These cavities provide room for silica precipitate concentration and when filled are termed amygdales.

In the case of lava coming in contact with muds (such as lake or streambed sediments), pillow basalts form, the interstices of which are filled with slightly altered sediments. In this case, CCS would most likely form in place and would exhibit color and textural differences due to variations in the surrounding sediments.

Jointing in basalt, which originates during cooling and is later amplified by weathering, also provides possible sites of CCS formation.

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APPENDIX H:
LITHIC SOURCES

by Dennis M. Hibbert

Attempts were made to locate sources for several kinds of lithic material utilized by the original inhabitants of the canyon. Sources were sought for:

tabular yellow quartzite
argillite
fine-grained chert
opal
chalcedony
nephrite

The commonly used granite and basalt were no doubt obtained locally; granite is the regional bedrock and basalt forms the south rim of the canyon as well as being locally abundant north of the river. Both rocks are common in the river gravels as well.

TABULAR YELLOW QUARTZITE

The nearest locality where this material is found in place was seen by this investigator just west and slightly north of the former rapids at Kettle Falls, along Highway 395, about 60 miles northeast of the Chief Joseph Dam Project headquarters. There is an operating quartzite quarry there today.

There is no reason to think the quartzite was brought from this source, however, since the gravels in the Columbia River contain an abundance of quartzite cobbles.

ARGILLITE

The even-grained black argillite known from project excavations has no nearby source area, nor is it common in the Columbia River gravels in the Project area. The region most likely to contain a source is the northeast corner of the State of Washington east of the Columbia and north of the Spokane River, where widespread metamorphosed fine-grained sediments are found. Several trips were made into the region in an effort to track down argillite occurrences reported in the geologic literature or described by geologists who had worked in the region, but no source was located.

FINE-GRAINED CHERT

Chert is abundant in the river gravels in the project area, but it is almost always more coarsely grained than the chert worked by the canyon's ancient inhabitants and recovered by project excavators. The abundance of fine-grained chert artifacts points to a source outside the canyon, but no such source was found. As in the case with argillite, the most likely source for fine-grained cherts, besides Columbia gravels, is the northeastern part of the State. A less likely but possible region is the mountainous country to the west of the Okanogan River.

It should be noted that a great deal of the materal identified by project lab workers as quartzite (other than the tabular yellow kind) is actually chert; therefore, chert is considerably more common as a lithic material than lab records indicate, and quartzite is considerably less common.

OPAL AND CHALCEDONY

Both these rocks occur within the basalts which make up the Waterville Plateau to the south of the project area. A large amount of opal is found above the river's south bank upstream from the upper end of the Grand Coulee (L. Salo, personal communication 1979), as well as near Quincy on the Plateau itself, while chalcedony (called agate when it displays banding) is a famous product of Plateau basalts at localities in both Washington and Oregon. The canyon's inhabitants probably obtained both these materials from the Plateau.

NEPHRITE

This investigator saw two nephrite adze-like objects in the project's lab collection. A local collector (name not recorded) also brought in a sawn water-worn cobble of nephrite which he said he found in the Sanpoil River to the northeast of the project area. As the nearest known source areas are far to the north in the drainage of the Fraser river in British Columbia, or west of the Cascades in the Puget Lowland, a search was made of the till in the project area to see if the Okanogan-Lobe ice may have brought nephrite south from Canada. Several pebbles of nephrite were found; it is thus assumed that the nephrite found in project excavations was brought south from Canada, embedded in glacier ice.

APPENDIX I:
PROJECTILE POINT CLASSIFICATORY DIMENSIONS

DIMENSION I: BLADE/STEM JUNCTURE

The blade of the projectile point is that portion defined by line segment aA or the distal or working end. It is demarcated by a node (A) signalling a change of direction in the point outline which either constitutes a shoulder or haft. The stem is that portion defined by line segments A1, A12, A123 or the proximal or hafted end of the projectile point. The juncture of blade and stem constitutes the shoulder and neck and is marked by node 1.

N. Not Applicable. Blade and stem are not marked by the presence of a shoulder or stem.

1. Side-notched. Blade and stem are separated by a deep lateral notch that creates a narrow neck and a sharply expanding stem which often approximates the maximum width of the blade.

2. Shouldered. Blade and stem are separated by a wide corner notch which has removed most of the proximal edge of the point preform. The shoulder and stem form an obtuse angle to the midline of the point, with the shoulder line slanting up fom the horizontal.

3. Squared. Blade and stem are separated by a narrower corner notch which has produced a shoulder line more nearly horizontal or perpendicular to the midline of the point.

4. Barbed. Blade and stem are separated by a very narrow corner notch that has created an extension of the blade margin down past the neck of the stem. The lateral tang or barb may roughly parrallel the stem margin, extending down to or past the base, and forming an acute angle to the midline of the point.

9. Indeterminate. Condition of the specimen precludes assignment to one of the above categories.

DIMENSION II: OUTLINE

All projectile points are treated as either triangular or lanceolate.

N. Not Applicable. The distinction cannot be accurately made.

1. Triangular. The broadest part of the blade (node A) occurs in the lower one-third of the point outline.

2. Lanceolate. The broadest part of the blade (node A) occurs in the middle one-third of the point outline.

9. Indeterminate. Condition of the specimen precludes assignment to one of the above categories.

DIMENSION III: STEM EDGE ORIENTATION

A stem is identified only if a shoulder and neck are present on the projectile point (line segment A1).

N. Not Applicable.

1. Straight. The margins of the stem form two lines roughly parallel to the midline of the projectile point.

2. Contracting. The margins of the stem converge with extension down from the blade-stem juncture.

3. Expanding. The margins of the stem diverge with extension down from the blade-stem juncture.

9. Indeterminate.

DIMENSION IV: SIZE

Size is an arbitrary division into large or small. Assignment to one or the other requires placement within two of three defining categories.

N. Not Applicable.

1. Large. Length is greater than 3 cm. Neck width is greater than 0.75 cm. Thickness at the blade-stem juncture is greater than 0.5 cm.

2. Small. Length is less than 3 cm. Neck width is less than 0.75 cm. Thickness at the blade-stem juncture is less than 0.5 cm.

9. Indeterminate.

DIMENSION V: BASAL EDGE SHAPE

N. Not Applicable.

1. Straight. The basal edge is essentially horizontal or pependicular to the midline of the projectile point.

2. Convex. The basal edge is rounded proximally, forming an oblique angle to the midline.

3. Concave. The basal edge is rounded distally, forming an acute angle to the midline.

4. Point. The basal edge terminates sharply, with margins converging proximally to form a point.

5. Straight or convex and centrally notched. A notch extends up into the stem from the basal margin.

9. Indeterminate.

DIMENSION VI: BLADE EDGE SHAPE

N. Not Applicable.

1. Straight. The lateral blade margin is a flat line, extending directly from the proximal end of the blade to the tip of the point.

2. Excurvate. The lateral blade margin bows out fom the midline of the blade.

3. Incurvate. The lateral blade margin bows in toward the midline of the blade.

4. Reworked. The lateral blade margin shows evidence of modification.

9. Indeterminate.

DIMENSION VII: CROSS SECTION

N. Not Applicable.

1. Plano-convex. The blade cross section is flattened on one surface.

2. Bi-convex. The blade cross section is rounded on both surfaces.

3. Diamond. The blade cross section is pointed on both surfaces.

4. Trapezoidal. The blade cross section has two parallel horizontal sides and steep edges.

9. Indeterminate.

DIMENSION VIII: SERRATION

N. Not Applicable.

1. Not Serrated. The lateral blade margin is not scored with multiple small notches.

2. Serrated. The lateral blade margin is scored with multiple small notches.

9. Indeterminate.

DIMENSION IX: EDGE GRINDING

N. Not Applicable

1. Not Ground. The lateral margins of the blade and haft have not been uniformly dulled.

2. Blade Edge. The lateral margin of the blade has been uniformly dulled.

3. Haft Edge. The lateral margin of the haft has been uniformly dulled.

9. Indeterminate.

DIMENSION X: BASAL EDGE THINNING

N. Not Applicable.

1. Not Thinned. The basal edge has not been reduced appreciably on either the dorsal or ventral surface.

2. Short Flake Scars. The basal edge has been reduced by removal of short flakes from either the dorsal or ventral surface.

3. Long Flake Scars. The basal edge has been reduced by removal of long flakes from either the dorsal or ventral surface.

9. Indeterminate.

DIMENSION XI: FLAKE SCAR PATTERN

N. Not Applicable.

1. Variable. Flake scars vary in size and orientation to the midline of the point.

2. Uniform. Flake scar size or orientation to the midline of the point is regular.

3. Mixed. Flake scar size and orientation ot the midline of the point is regular on some sections of the surface.

4. Collateral. Flake scar size is regular and flake scars are parallel to one another and perpendicular to the midline of the point.

5. Transverse. Flake scar size is regular and flake scars are parallel to one another and oblique to the midline of the point, carrying from lateral edge to lateral edge.

6. Other. Flake scar size is uniform and flake scar orientation is other than collateral or transverse.

9. Indeterminate.

HISTORICAL TYPE CLASSIFICATION

DIVISION	LANCEOLATE		TRIANGULAR			
SERIES	SIMPLE	SHOULDERED	SIDE-NOTCHED	CORNER-REMOVED	CORNER-NOTCHED	BASAL-NOTCHED
TYPE	11 11 LARGE LANCEOLATE	23 12 LIND COULEE	31 41 COLD SPRINGS	41 51 NESPELEM BAR	51 61 COLUMBIA A Corner-notched	61 71 QUILOMENE A Basal-notched
	12 15 WINDUST C Contracting base	21 13 WINDUST A	32 42 PLATEAU Side-notched	42 52 RABBIT ISLAND A	52 62 QUILOMENE Corner-notched	62 72 QUILOMENE B Basal-notched
	13 21 CASCADE A	22 14 WINDUST B		43 53 RABBIT ISLAND B	53 63 COLUMBIA B Corner-notched	63 73 COLUMBIA STEM A
	14 22 CASCADE B	24 31 MAHKIN SHOULDERED			54 64 WALLULA Rectangular stemmed	64 74 COLUMBIA STEM B
	15 23 CASCADE C					65 75 COLUMBIA STEM C

Types are numbered consecutively within formal series: a two-digit code indicates the approximate temporal sequence of defined series and types

Type names are those most commonly applied. Mahkin Shouldered and Nespelem Bar are types defined for the Rufus Woods Lake project area

Figure I-1. Key to changes in projectile point type numbers. (This figure, which appears in most of the descriptive site reports, has been modified to show the correspondence between the numbering system used in the descriptive site reports [small numbers] and the numbering system used in the summary report [large numbers].

APPENDIX J: ADDITIONAL BOTANICAL INFORMATION

by Nancy A. Stenholm

This appendix presents background information on plant resources in the project area too detailed to be included in the body of the text or previous documents. First are descriptions of the project area vegetation which draw on the author's personal field observations. The second section presents details of harvesting experiments referred to in Chapter 13.

DESCRIPTION OF VEGETATION BY BIOPHYSIOGRAPHIC ZONE

The following description of the vegetation communities is organized by the biophysiographic zones defined for the project (see Chapter 1 for discussion). The descriptions are based on original field observations made during a three-year stay in the project area. Information on plant use by local Indian groups was derived from Ray (1932), Spier (1938), Turner (1978, 1979), and Turner et al. (1980).

BIOPHYSIOGRAPHIC ZONE I

There is no contiguous riparian community along Rufus Woods lakeside today. Before the latest pool rise (February 1982), a few localities, mostly limited the to the mouths of draws, held some willow (*Salix* spp.), a few bulrushes (*Scirpus acutus*) and sedges (*Carex* spp.) and common horsetail (*Equisetum* spp.) along with plants common in other zones such as hackberry (*Celtis douglasii*), ponderosa pine and other water tolerant draw vegetation. The beach gravels hold weedy introduced plants such as mullein (*Verbascum thapsus*), lady's thumb and knotweed (*Polygonum persicaria*, *P. aviculare*), plantain (*Plantago major*), amaranth (*Amaranthus albus*, *A. retoflexus*), and cheat grass (*Bromus tectorum*) among others. Before the completion of Grand Coulee Dam, the river itself was an important supplier of building materials. A local inhabitant remembers the time when cedar logs were collected by boat, split into fence posts and sold. A number of potentially useful conifer and hardwoods can be seen today in trash piles above major dams. Driftwood no doubt provided the bulk of winter fuel and a substantial amount of ready lumber for construction in the past.

BIOPHYSIOGRAPHIC ZONE II

This zone, which extends on both sides of the river at elevations ranging from about 1000 ft (300 m) to 2000 ft (600 m), contains several distinct communities. The zone includes relatively flat terraces with deep soils, interior valley systems such as the Omak Trench and the Nespelem River Valley, granitic and basalt hillsides, rocky outcrops, steepsided draws, and few bodies of water at higher elevations. Most of the land has been grazed and some of it has been dry-farmed or irrigated, with the result that very little flat land contains original climax vegetation (Daubenmire's *Artemisia tridentata/Agropyron spicatum* habitat type). Big sage and wheatgrass probably covered most of the terraces and flats to about 2000 ft (600 m). In drier locales (regions with sandy soil or on gentle south-facing slopes), wheatgrass was replaced by needle grass (*Stipa comata*), one of the so-called bunchgrasses. In wetter locales, north facing slopes at low elevations, or flats at higher elevations, wheat grass is replaced by Idaho fescue (*Festuca idahoensis*). Good stands of native bunchgrasses can still be seen on the south side of the river above irrigated fields. Both wheatgrass and fescue are found together interspersed with occasional bushes of sage. Grazing has destroyed most of the bunchgrasses but they may still be seen on the south side of the river above irrigated fields. Both wheatgrass and fescue are found together interspersed with occasional bushes of sage. Grazing has destroyed most of the bunchgrass association on the north side of the river and opened the habitat to annual cheat grass (*Bromus tectorum*). Sage cover has often been reduced with a resulting increase in rabbitbrush (*Crysothamnus nauseosus*). Abandoned fields support knapweed (*Centaurea diffusa*) and mobile tumbleweeds (*Salsola kali, Sisymbrium altissimum*), to name only a few of the recently arrived noxious weeds.

Useful plants that may still be seen on the terraces in places include Indian celery (*Lomatium ambiguum, L. triternatum*), white camas (*L. geyeri*), Desert or sego lily (*Calochortus macrocarpus*), sunflower (*Helianthus annuus*), sumac clumps (*Rhus glabra*), and occasional ponderosa pine, serviceberry (*Amelanchier alnifolia*), hawthorn (*Crataegus douglasii*) and Oregon grape.

Stands of bitterbrush (*Purshia tridentata*) dot hillsides and cluster at the base of hills where they may mingle with sagebrush. Bitterbrush thickets support native dropseed grass (*Sporobolus* spp.). The grass is palatable to cattle, but the ruggedness of the terrain in steep granitic hillsides may have helped preserve this grass. On south-facing hillsides bitterbrush individuals are widespread. Cheat grass is found wherever cattle have found space to graze the slopes.

In sandy areas a fragile community exists on south-facing slopes composed of spring sunflower, chocolate tips (*Lomatium dissectum*) and clumps of buckwheat (*Eriogonum niveum*). Both the sunflower and chocolate tips possess large storage roots which enable the plants to take advantage of the first warm rays of sun and put forth the first edible shoots of spring.

The bases of rockfalls and talus slopes support a garland community of shrubs common to both sides of the river. Rainfall and other moisture absorbed through rock fissures is used by mesic shrubs and herbs. The community is similar to that encountered in draws and includes mockorange (*Philadelphus lewisii*), serviceberry (*Amelanchier alnifolia*), wild rose (*Rosa woodsii*), cherry (*Prunus virginiana*), snowberry (*Symphoricarpos albus*) and hackberry (*Celtis douglasii*). Occasional bushes of wild currant (*Ribes cereum*), purple sage (*Salvia dorrii*), and hawthorn are found here. White clematis (*Clematis liguisticifolia*), an important fiber plant, covers the rocks and bushes. Thus this community contains many useful species including edible fruits (serviceberry, rose hips, cherry, currant, hawthorn fruits and hackberries), wood resources (mockorange, serviceberry, cherry, hawthorn, and hackberry), cordage, and sweatbath material (purple sage). The talus community is attractive to birds year round thus offering people in winter camps or villages a nearby source of protein.

Draw bottoms and moist canyons are covered with a complex association of plants. In addition to those mentioned in the talus association, draw flora include water-loving species such as willow (*Salix fluviatalis*, *S. exigua*, *S. lasiandra*), alder (*Alnus sinuata*), western birch (*Betula occidentalis*) and quaking aspen (cottonwood, *Populus tremuloides*). Under shade, draw bottoms are covered in poison ivy (*Rhus radicans*), bedstraw (*Galium aperine*), edible miner's lettuce (*Montia perfoliata*), and false solomon's seal (*Smilacina racemosa*) which has edible roots. Wild mints (*Mentha arvensis* and *Monardella odoratissima*) are common. Members of the talus community are found a few meters from running water along with ponderosa pine, an occasional Douglas fir or juniper tree, dogwood (*Cornus stolonifera*) and thickets of Oregon grape (*Berberis acquifolium*). Plants producing fiber and useable bark include willow, birch, stinging nettle (*Urtica dioica*), and Indian hemp (*Apocynum cannabium* and other species). Where the land is flat and marshy areas are created, bulrushes (in the middle and upper parts of Zone II), coltsfoot or cow parsnip (*Heracleum lanatum*) and poison hemlock (*Cicuta douglasii*).

There are numerous small ponds and a few large lakes in the glacially modified topography of B-P Zone II and III. Some of these form freshet strings such as the Buffalo/Rebecca Lake series south of Nespelem or those of the Omak Trench (Omak/Goose/Alkalai Lake series). Others such as Black Lake on the basalt plateau in Douglas County are more alkaline. Flora varies. In general, however, the approach to lake or pond shore is covered with cord grass (*Spartina gracilis*) or salt grass (*Distichlis stricta*) on alkaline soil. Giant ryegrass (*Elynus cinereus*) may grow in soil not excessively alkaline. Along the borders of the lake are sedges (*Carex* spp.), and stands of bulrush and cattail (*Typha latifolia*) in several meters of water. Bulrush is useful for mat-making and cattails provide food and materials for flexible construction of various kinds. The importance of these small lakes and ponds above the floodplain is enhanced by their nearness to the major root producing grounds. The riparian community of ponds was attractive to water fowl.

Lithosols (rocky soils) are known for their diversity of *Lomatium*, onion, and wild mustard species (Daubenmire 1970:30). Thin soils over basalt to the south, and over granite to the north of the river from approximately 1200 ft (360m) to 2500 ft (750 m) in Zone III support fairly dense stands of these spring edibles even on grazed land. Thus the lomatium hilltop communities thrive in Zone III as well as Zone II.

In at least one location, this community is in pristine condition. Agricultural land overlooking Bissel Flat has been closed to grazing for some time; consequently hillsides and exposed hilltops show little denudation (swales and valley bottoms are dry-farmed). At elevations of 1800 ft (540 m) the hills are clothed in vigorous stands of bunchgrass and scattered sage. The grass and sage are more mesic species (that is, *Festuca idahoensis, artemisia tripartita*) on northfacing slopes, but big sage and wheatgrass are still present. Indian paintbrush (*Castelleja*, a medicinal plant), nodding onion (*Allium acuminatum*), death camas (*Zigadenus venenosus*, an arrow poison), spring sunflower and Indian celery (*Lomatium ambiguum*) are found among the tussocks. Exposed rocks are clothed by a layer of colorful lichens and mosses. Finely dissected leaves of white camas (*L. canbyi*) and desert parsley (*L. macrocarpum*) hug the ground, and an occasional waxy pink bitter-root blossom (*Lewisia redivia*) may be spotted next to cushions of phlox, and bright yellow clumps of daisy fleabane (*Erigeron linearis*). By the time these and other flowers have faded in June, the leaves of the economic species have commonly dried and blown away although they may persist to July in upper draw regions.

The same community can be found on the north side of the river in depauperated form. The edible triumvirate of camas, onion, and bitter-root can best be viewed in abundance around Rebecca Lake, and in stony ground on Goose Lake flats. A few communities can also be spotted on open hillsides and terraces in draws up to the ponderosa pine zone.

In sum, Zone II possesses several distinct habitats and vegetation communities useful for foragers of the past. Some of the roots and nearly all of the berries collected for storage by Indians in the ethnographic past are from this zone.

BIOPHYSIOGRAPHIC ZONE III

This zone is located in Douglas County, begins about 2000 ft (600 m) and rises to about 2500 ft (750 m) at a distance of 4 km from the river. As mentioned in a previous section, the plant community is much the same as that encountered in upper Zone II on the Douglas County side of the river. The flat basaltic landscape is dotted with small farms and ranches and shallow ponds. Here the big sage/wheatgrass zonal association is replaced by the *A. tripartita/Festuca idahoensis* zonal association (Daubenmire 1970). Portions of the vegetation can be seen in a relatively undisturbed state around Banks Lake. A few conifers, including ponderosa pine and Douglas fir (*Pseudotsuga menziesii*) appear. A talus garland community similar to that of Zone II is found in places and the lomatium community exists among the sage on rocky ground. Zone III, however, has more lomatium species.

BIOPHYSIOGRAPHIC ZONE IV

The last zone in our transect is largely forested upland above 2000 ft (600 m) in the Okanogan uplands. Some land exists without forest in this zone. The Omak Plateau is largely devoid of trees although it rises above

2000 ft. Vegetation communities there are similar to that of Upper Zone II in the Omak Trench and Zone III.

We will extend discussion of the forest region to include mountainous areas up to the elevation of Summit Lake, about 3500 ft (1000 m) since the area was frequented by native peoples. The forest can be divided into three communities based largely on elevation: ponderosa pine from 2000 ft (600 m) (actually the forest begins at about 1400 ft (450 m) in canyons and draws and even lower on northfacing slopes) and extends to about 2500 ft (750 m). From there to about 3000 ft (900 m) Douglas fir is dominant. The beginnings of the alpine fir (*Abies lasiocarpa*) and spruce (*Picea engelmannii*) community can be seen on mountain tops above the fir zone.

Although there are differences in underbrush in each of the forest communities, a general floral picture is presented. This description applies mostly to the Douglas fir belt around Summit Lake.

The forest community consists mostly of Douglas fir, interspersed with lodgepole pine (*Pinus contorta*), larch (*Larix occidentalis*) in wet areas, and a few ponderosa pines and spruce trees. The larch trees in particular are covered with edible lichen ("black moss," *Alectoria fremontii*), one of the few aboriginal foods available year round. Foam berry (*Shepherdia canadensis*) from which Indian "ice-cream" is made, mountain huckleberry (*Vaccinium* spp), kinnikinnick (*Arctostaphylos uva-ursi*), and thimbleberry (*Rubus parviflorus*) are some of the more important edibles abundant in this zone. Several kinds of mushrooms can be picked from spring to late fall including diverse members of the *Boletus*, *Hygrophorus*, *Polyphorus*, and *Suillus* families. Prized for arrow shafts, ironwood (*Holodiscus discolor*) bushes abound. Dogwood (*Cornus stolonifera*) also found in draws is abundant and was collected for edible berries as well as medicine. Birch trees grow to sufficient size to provide suitable raw material for containers. Marshes, lakes, and upper fingerings of creeks support upland willow and yellow pond lily which can be harvested for seeds. Occasional stands of hazel nut and serviceberry bushes are also found in forest openings. Wild strawberry carpets part of the forest floor.

In general the forest offers fruits that ripen (except for strawberry) later than their counterparts in the lower draw communities, arborescent raw materials (bark, nuts, boughs, sap, resin and cambium), and certain plants (foamberry, huckleberry) not found in any other region.

HARVESTING EXPERIMENTS

Lomatium macrocarpum

Two collections of L. macrocarpum give us some idea of seasonality and productivity of this important food resource. The first was made on the Douglas County side of the Columbia River at 570 m (1900 ft) across from Panama Canyon on June 10, 1980. The second was among scattered ponderosa pines at 450 m m.s.l. in Coyote Canyon on July 19, 1980. By then, the dried tops of the plant had broken away from the stalk but were lying close enough to serve as an excavation aid.

The Douglas County harvest was of particular interest because of the technique of root extraction we had to adopt among the rocks. The rocky hilltop where harvest took place had not been grazed recently and native bunch grasses and wild flowers were prolific. Rocks and basalt spalls made digging difficult, nevertheless, six roots with a fresh peeled weight of 51 g were collected in 30 minutes, and the largest specimen weighed 28 g. In order to harvest the roots it was necessary to make an initial hole by prying out the rocks and then remove the roots as the hole was continually enlarged in one or more directions. When we had finished, an oval hole some 10-15 cm deep and 65 cm across had been created. After the rocks had been replaced and the scars of the excavation removed, it was noticed that there were other similarly filled depression on the hilltop. Harvesting must have taken place some time ago as the rocks were lichen-coated and soil had drifted among the replaced rocks. We may have discovered an archaeological signature for root extraction in rocky soil.

The Douglas County harvest was interesting also for the edible plants in association. Those worth collecting included bitter-root (Lewisia redivia), Indian celery (Lomatium ambiguum), and wild onion (Allium acuminatum). All three were flowering and the small roots, leaves, and heads of the last two could be used for flavoring.

The second harvest was made in Coyote Canyon after the plants had dried and fallen apart. A square meter was staked out and the roots collected from that area. Dried stems and leaves marked the approximate position of 14 plants. We collected 13 in 30 minutes, although not all of the roots were entire. The harvest weighed 135 g in the field, and 94 g cleaned and peeled for eating. Excavation was easier in the terrace soil than the rocky outcrop of the first harvest, but the root size remained about the same.

Edible plants in the immediate area included the dried remains of a second Indian celery (L. triternatum) whose seeds are useful seasoning (Turner et al. 1980:70), and wild currant (Ribes cereum) past its prime. And within a stone's throw near the creek, were first quality serviceberry bushes (Amelanchier alnifolia) with some good fruits available, and Oregon grape stands (Berberis acquifolium) in prime picking condition.

In short, lomatium roots are easiest to spot in spring, but can still be gathered in mid-summer if the dried foliage hasn't been disturbed or blown away. Depending upon the soil they are relatively easy to harvest, dry well (they lose about 40% moisture content), and are easy to clean and peel. They are found with other edible plants, such as onion, Indian celery, and bitter-root, that might be gathered along with the roots. The discovery that there is a way of digging for this lomatium by trenching where the soil is rocky may be of use in spotting harvesting sites. The distinctive scars are long-lived.

Prunus virginiana

Wild cherry fruits grow on racemes that contain seven to 12 edible fruits. These can be gathered by stripping or taking the entire branch to be picked over later. During one 16 minute session an inexperienced picker harvested 1505 cherries weighing 1025 g. The edible portion, consisting of flesh and skin, weighed 825 g, and the fresh pits weighed 200 g. From this and other harvests is was found that the average ripe chokecherry weighs 0.69±0.2 g (N=1556) and contains from 82 to 89% flesh and skin by weight. The taste is tart and slightly astringent, and some find it unpleasant. The quality improves with cooking and possibly with drying.

In other words, wild chokecherries are fairly small, but they are easy to gather. Apparently the easiest way to handle them for winter use is to mash them pit and all and dry them as cakes to be served with other ingredients.

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